SCIENTIFIC AGRICULTURE

Vol. XVI SEPTEMBER, 1935 No. 1

AVAILABILITY OF NUTRIENTS IN RASPBERRY PLOTS IN RELATION TO WINTER INJURY[1]

J. J. Woods[2]

Dominion Experimental Farm, Agassiz, B.C.

EXPERIMENTAL

In the spring of 1930 Cuthbert raspberry plots were planted out at the Dominion Experimental Farm, Agassiz, B.C., to determine the effect on cane growth as affected by green manure companion crops of rye, clover and vetch, and barnyard manure and complete fertilizer. In 1930 the whole area was clean cultivated, and the different treatments were commenced in the spring of 1931, and have been repeated each year since that time. Each plot consisted of two adjacent 50-foot rows, $7\frac{1}{2}$ feet apart. All plots were separated by guard rows. Fourfold replication was used, each treatment occurring once in each of four blocks. Rye and vetch have been seeded at the rate of 112 pounds per acre in March or April, as weather conditions permitted, and clover at 20 pounds per acre. Throughout the period of experimentation the first two crops have given more satisfactory growth than clover and have been ready for ploughing down before the picking season commenced. Fertilizer consisting of a 5-10-6 mixture has been applied at 750 pounds per acre and barnyard manure at 13 tons per acre, applied at the same time as green manure crops have been seeded. Check plots receiving no treatment were replicated throughout the area, and were cultivated along with the fertilized and manured plots during the growing season in order to keep down weeds.

Commencing in March 1931, soil samples from each treatment were taken at two-monthly intervals and included March, May, July, September, and November, 1931, and March 1932. Each sample was a composite of the four plots and was air dried and analyzed at the plant nutrition laboratory, Department of Horticulture, University of British Columbia, in the spring of 1932. The results of these analyses reported by Harris and Wood (*1*), showed in particular a marked increase in concentration of nitrate and potassium ions under fertilized, manured, and clean cultivated plots, as compared to rye, clover and vetch plots.

FIELD RESULTS

During the winter of 1932–33 unusual weather conditions prevailed and were such that greater injury resulted to raspberry plantations than had ever been recorded dating back to 1885, when small fruit production was commenced in the Fraser Valley of British Columbia. The injury

[1] Paper read at the annual meeting of the Horticultural Group of the C.S.T.A. at the University of Alberta, Edmonton, Alta., June 25–26, 1935.

[2] Assistant Superintendent.

resulted not so much from an unusually low temperature as from a sudden drop in temperature which had been preceded by very mild weather in October, November, and early December. The first recorded frost in a standard Stevenson screen was on December 6th, when a minimum of 29° F. was recorded. On December 7, 8, and 9, the temperatures were respectively 14°, 13°, and 18° F. above zero. Examination of canes and buds shortly after this date showed that very considerable injury had resulted, which was manifested by a shrivelling and withering of the affected parts.

FIGURE 1. Injury and new growth in vetch plots in the spring of 1933.

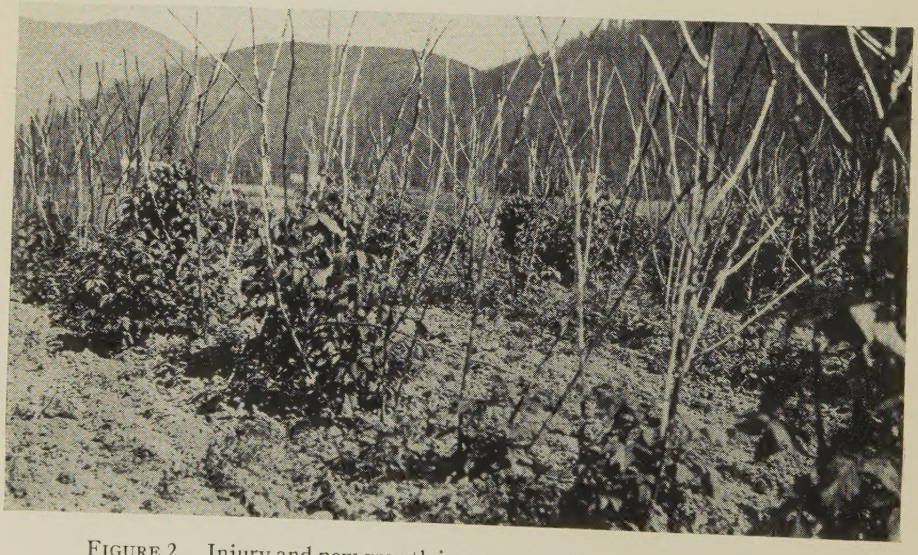


FIGURE 2. Injury and new growth in manured plots in the spring of 1933.

In the spring of 1933 efforts were made to record the injury by exact measurements rather than to rely on yield records during the fruiting season. Accordingly when growth conditions were well advanced in 1933 and when it was apparent that no further bud growth would occur, a count was made of the number of living and dead canes on each plot. A living cane was taken as one having on it one or more growing buds. No definite standard was set as to what constituted a fruiting cane when thinning out of growth was done in the fall of 1932, the canes left, however, would closely approximate conditions found in commercial plantations. Table 1 gives the results obtained.

TABLE 1.—NUMBER OF LIVING AND DEAD CANES

Treatment	No. of canes	Living	Killed	Per cent killed
Rye	610	355	255	41.8
Clover	617	316	301	48.7
Vetch	608	362	246	40.5
Manure	657	109	548	83·4
Fertilizer	607	144	463	76.3
Cultivation	659	216	443	67.2

The figures readily indicate that manured, fertilized, and clean cultivated plots suffered considerably greater injury than did plots treated with rye, clover, or vetch.

Comparable data were obtained when a count of the number of living buds on 400 canes was recorded, counting the number of living buds on the first fifty canes of each of the eight rows for each treatment. The results are shown in Table 2.

TABLE 2.—NUMBER OF LIVING BUDS ON 400 CANES

Treatment	Total 400 canes	Average per cane
Rye	1389	3.47
Clover	985	2.46
Vetch	1460	3.60
Manure	186	0.46
Fertilizer	362	0.90
Clean cultivation	674	1.68

The degree of protection afforded by the different treatments is perhaps best understood when it is realized that the average Cuthbert cane has approximately 22 fruit buds in the second to fifth foot of cane, which is the main fruiting section.

It is common knowledge among raspberry growers that some varieties tend to branch very considerably especially during the first and second years of growth. The Cuthbert variety exhibits this characteristic more consistently than most other kinds. The author has not been able to find any reference to this habit in literature, nor in correspondence with experimenters has he been able to obtain any consistent opinion as to what

conditions induce this habit of growth. Results from the experimental plots under discussion indicate that branching is a measure of response in relation to the amount of available nutrients as contrasted between green manure companion crops and other treatments under consideration. Table 3 shows the relative number of branched and unbranched canes in the different treatments and the relative hardiness between the two kinds.

TABLE 3.—AMOUNT OF INJURY TO BRANCHED AND UNBRANCHED CANES

Treatment	No. of canes	Branching	Perc cent killed	Non-branching	Per cent killed
Rye	169	41	73	128	22
Clover	203	45	71	158	27
Vetch	190	37	67	153	40
Manure	186	76	98	110	82
Fertilizer	166	57	89	109	80
Cultivation	176	47	86	129	54

The data show that where growth is stimulated as manifested under manured and fertilized plots, branching of canes is more prevalent and that this kind of growth is considerably more subject to winter injury than is the more normal straight habit of growth.

Since the experimental area was planted in 1930 it has been a routine practice to count the number of fruiting canes produced each year. Table 4 gives the results so obtained.

TABLE 4.—FRUITING CANES GROWN IN THE YEARS 1931–1934 INCLUSIVE

Treatment	1931	1932	1933	1934
Rye	550	610	526	560
Clover	523	617	456	482
Vetch	559	608	480	532
Manure	586	657	366	457
Fertilizer	613	607	313	434
Cultivation	586	659	494	507

It is shown that for the two years preceding the severe winter of 1932–33 the green manure companion crop group of plots produced a lower average number of canes than did the remaining plots, and that for the two years following this winter the results are reversed. One of the outstanding effects of the winter under discussion was the large amount of root and crown injury which occurred. While varying degrees of cane and bud injury during recent years have been of quite common occurrence, root and crown injury in well drained land is seldom experienced. Approximately the same degree of injury was sustained by these parts of plants as in the case of canes and buds, and the various treatments manifested the variable degree of hardiness. The illustrations show the comparative amount of growth which developed in 1933 between a manured and a vetch plot lying adjacent to one another.

The crop yields from the different treatments during the period 1931 to 1934 inclusive are given in Table 5.

TABLE 5.—CROP YIELDS IN POUNDS

Treatment	1931	1932	1933	1934
Rye	90	233	79	151
Clover	101	236	78	126
Vetch	94	240	86	135
Manlre	93	239	15	91
Fertilizer	101	222	12	75
Cultivation	98	296	56	127

The yields in 1931 and 1932 were comparatively uniform, except that in 1932 clean cultivated areas gave an appreciably higher yield than did any other treatment. In 1933 and 1934 the yields were markedly depressed, more especially in manured and fertilized plots, while in the clean cultivated plots in 1934 the yield exceeded that of the clover treatment.

DISCUSSION

The literature pertaining to fertilizers for raspberries is somewhat limited, and numerous references deal with practices more than with results established on experimental data. A general recommendation is to maintain an adequate supply of humus, supplied in the form of barnyard manure and the ploughing down of green manure crops either before or after the plantation is established. Chandler (*2*) concludes after his review of literature that nitrogen and humus are the most important additions to promote good growth but that nitrogen may increase growth without giving a corresponding increase in yield. Knowlton and Orton (*5*) found that on a poor soil in Virginia a 300-pound application of nitrate of soda in September gave the best results on a Latham patch. The same authors advocate the use of cover crops seeded after the harvesting season. Loree (*6*) in referring to field experiments in Michigan states that nitrogenous fertilizers at 200 to 250 pounds per acre are beneficial while other mineral elements are of no use except to promote cover crop growth. Swartwout (*10*) states that heavy applications of nitrogenous manures will cause excessive growth at the expense of fruit production. Lott (*7*) in Missouri, found that a late summer cover crop of oats with a fall application of nitrate of soda gave a greater degree of hardiness than any other treatment. The cover crop induced a greater drying out of the fruiting plants. Slate and Rankin (*8*) in New York, state that nitrogenous fertilizers will stimulate growth and should be applied in early spring in order to prevent the stimulation of late fall growth. These authors state that phosphoric acid and potash have not been shown to be profitable in experiments with raspberries. Strong (*9*) in Ontario refers to beneficial effects from applications of equal parts of acid phosphate, bone meal and muriate of potash applied at the rate of 500 pounds per acre. The same author refers to a field experiment in Western Oregon in which an application of "1000 pounds of acid phosphate per acre one year, followed by annual applications of 100 pounds of acid phosphate plus 100 pounds potash plus a light dressing of manure showed very much less winter

injury than where no fertilizer was applied." Antoshin (*1*) reports raspberries as responding readily to N, but very little to P and K. In an editor's note the statement is made that raspberries are susceptible to potassium deficiency. Hoblyn (*4*) at East Malling states that nitrogen up to a point may produce more cane but if this is overdone the cane growth may be reduced, while for crop nitrogen alone has been not only ineffective but inadvisable except in the presence of potash which when applied as the sulphate has always proved beneficial. He further states that a proper balance between nitrogen and potash is the secret of successful manuring of raspberries and that on the whole sulphate of potash is superior to kainit.

The author in unfinished experiments has data showing that nitrate of soda increases cane growth more than any other single element tried, that in combination nitrate of soda and superphosphate of lime have produced the greatest amount of growth, and that muriate of potash when applied as a single element or in combination at the rate of 1000 pounds per acre inhibits growth.

The above references indicate especially the increased growth that may chiefly be obtained from applications of nitrogenous fertilizers and from a soil well supplied with humus. They do not, however, in any specific way refer to winter injury which may result from different manurial practices. The data submitted in the body of this report show increased growth where there is an abundance of plant nutrients, as indicated by applications of manure and fertilizer and as demonstrated by laboratory analyses of soil samples from the various treatments. The increased available nutrients tend to increase the size of canes, and such increased growth to a large extent is manifested by branching canes, which on the whole are more subject to winter injury than are smaller unbranched canes. Where green manure cover crops are planted between the rows and compete with the fruiting plants for nutrients and moisture to the extent that cane growth is curtailed increased hardiness is induced. It remains, however, entirely within the realm of possibility that continuous ploughing down of cover crops, especially those of a nitrogenous nature, will increase the humus content of the soil to a point where growth of fruiting plants will be stimulated to the extent that increased injury will result. Furthermore it must be born in mind that the data submitted have been obtained from only one particular field area where growth without manurial treatments has proved satisfactory. The native fertility of any given area will under practical conditions be a determining factor in the responses obtained. Where the natural fertility is low there is every possibility that cover crops will exert a too serious competition with the fruiting plants and growth may consequently be stunted. In such cases the cover crops would need to be stimulated with artificial fertilizers. In certain areas fertilizers are often necessary to produce canes of good size. Over the wide range of soil conditions under which raspberries are grown no one general rule can be laid down as to what will prove the best manurial practice. Growers in general must determine for themselves the practices which are most suitable for their conditions and must in particular note that where growth is appreciably stimulated that increased winter injury does not result.

SUMMARY

1. Evidence has been submitted showing that more plant nutrients are available in raspberry plots which have been fertilized, manured or clean cultivated, as compared to plots growing green manure cover crops.

2. Increased nutrients tend to cause a more branching habit of growth, and such growth is more susceptible to winter injury than are less vigorous canes such as are produced in cover crop plots, and that within plots branched canes suffer greater Injury than unbranched canes.

3. Under severe winter conditions more injury is caused to the crown and root systems where nutrients are most plentiful.

4. Finally, it is assumed that the native fertility of the soil will have a direct bearing as to what will prove the best manurial practice in the various conditions under which raspberries are grown.

REFERENCES

1. Antoshin, S. T. Experimental data on orchard and small fruit manuring. Imp. Bur. of Fr. Pro. Occ. paper No. 2.
2. Chandler, W. H. Fruit Growing. Houghton Mifflin Co. 1935.
3. Harris, G. H. and Woods, J. J. Raspberry Nutrition 1, Seasonal variations of plant nutrients in raspberry plantings under different cultural practices. Sci. Agri. Vol. 25, No. 8, 1935.
4. Hoblyn, T. N. The layout and conduct of two manurial trials of raspberries. Jour. of Pom. and Hort. Sci. Vol. IX, No. 4. 1931.
5. Knowlton, H. E. and Orton, C. R. Growing raspberries in West Virginia. West Virginia Agri. Exp. Sta. Cir. 61. 1933.
6. Loree, R. E. Raspberry Growing in Michigan. Michigan Agri. Exp. Sta. Cir. Bul. No. 152. 1934.
7. Lott, R. V. Correlation of chemical composition with hardiness in brambles. Missouri Agr. Exp. Sta. Res. Bul. 95. 1926.
8. Slate, G. L. and Rankin, W. H. Raspberry Growing in New York State. New York State Agr. Exp. Sta. Bul. 625. 1933.
9. Strong, W. J. The Raspberry and Blackberry in Ontario. Vineland Hort. Exp. Sta. Bul. 355. 1930.
10. Swartwout, H. G. Blackberries, Raspberries and Dewberries. Missouri Agri. Exp. Sta. Bul. 265. 1929.

Résumé

Assimilabilité des principes fertilisants dans les parcelles de framboisiers. J. J. Woods, Ferme expérimentale fédérale, Agassiz, C.-B.

Les preuves soumises établissent que les parcelles de framboisiers fertilisées au moyen d'engrais chimiques, ou de fumier ou tenues propres par des binages, contiennent plus de principes fertilisants que celles qui ont porté une plante-abri, enfouie comme engrais vert. Cette forte fertilisation tend à provoquer une végétation plus branchue, qui est plus aisément affectée par l'hiver que les tiges produites dans les parcelles où pousse une plante-abri; les tiges branchues dans ces parcelles souffrent plus que les tiges non branchues. Pendant les grands froids, le collet et les racines des framboisiers sur terre très engraissée sont plus abîmés qu'ailleurs. Enfin, l'auteur est d'avis que l'on pourrait se régler sur la fertilité du sol au début pour trouver les meilleures pratiques de fertilisation à employer dans les différentes conditions sous lesquelles les framboisiers sont cultivés.

WINTER INJURY TO APPLE TREES IN EASTERN CANADA 1933-35[1]

D. S. Blair[2]

Central Experimental Farm, Ottawa

SURVEY OF WINTER INJURY

The extent of the tremendous damage to the apple trees in Eastern Canada wrought by the severe winter of 1933–34 will not be fully known until late in 1935. A survey, however, of the injury to date in Nova Scotia, New Brunswick, Prince Edward Island, Quebec and Ontario, reveals that its havoc particularly in Eastern Ontario, will long be remembered by all those interested in fruit growing. These effects are clearly pictured in Table I, wherein data are presented from the Dominion Bureau of Statistics showing the commercial production in these provinces, with the exception of Prince Edward Island, in 1934 as compared with previous years.

Table 1.—Commercial production of apples

Province	1934*—brl.	1933—brl.	5 yr. average 1929–33—brl.
Nova Scotia	1,800,000	2,438,000	1,530,200
New Brunswick	30,000	55,000	41,800
Quebec	121,000	306,500	216,300
Ontario	320,610	1,068,700	881,800
Total for the four provinces	2,271,610	3,868,200	2,670,100

* Preliminary.

Table 1 shows the 1934 crop in Ontario and Quebec to be 60.5% and 70%, respectively, less than in 1933 and 44% and 63.6%, respectively, below the five-year average. Due to the drastic reductions in these two provinces, the commercial production in Eastern Canada in 1934 was 41.3% less than in 1933 and 14.9% below the 1929–33 average. The figures, particularly in comparison with the five-year average, are highly significant when one considers the recent increasing trend in production in the provinces of Nova Scotia and Quebec.

Most of the many forms of winter-killing so ably described by the late Dr. Macoun in the Dominion Department of Agriculture Bulletin No. 86, *The Apple in Canada*, were observed. These, listed in order of importance, were as follows: (1) trunk or body injury, (2) crotch injury, (3) sunscald, (4) bark splitting, (5) killing of dormant buds, (6) killing back, (7) black heart, (8) discoloration of the sap wood, and (9) trunk splitting. For the sake of convenience, these may be divided into two general classes: (1) injury to the leaf and fruit buds; (2) injury to the wood tissues above the ground. The killing of leaf and fruit buds was common, but although the loss of the latter was a serious economic factor, this accounted for very little of the permanent damage. The injury that occurred to the wood tissues above the ground was far more destructive, accounting for the

[1] Contribution from the Horticultural Division. Read before the annual meeting of the Horticultural roup of the C.S.T.A. at the University of Alberta, Edmonton, Alta., June 00, 1935.

[2] Graduate Student.

major part of the permanent damage. This is well illustrated in a recent statistical report issued by the Quebec Department of Agriculture, where the data show that the actual number of trees killed outright in 1933–34 in the Montreal fruit districts was 8%. Death or severe injury to the base of the main branches, the crotch, and that part of the trunk between the snow line and a few feet up the branches, was responsible for the majority of the tree losses. Some of the trees were killed from the top to the ground, but usually the tops were uninjured except for terminal killing and black heart. The complete killing was in main the result of a lack of maturity in the tissues at the time of the early freeze-up, November 11th and 12th. The fact that this was the main contributing factor in the frost injury was further borne out by the McIntosh, Fameuse, Melba and Joyce trees under nutritional studies at the Horticultural Division, Central Experimental Farm, Ottawa. These pot trees were, on November 14th, put into winter storage in a frost-proof cellar, and following their removal in the spring to their outdoor site, failed to break bud. A close examination of the bark, cambium, sap wood, leaf and fruit buds, revealed that, roughly, 80% of these trees were completely killed. This proved, without a doubt, that these trees were not sufficiently hardened off to withstand the low temperatures previous to November 14th. A similar lot of trees, i.e., trees of the same varieties, age, and budded on the same type of stock as those used in the nutritional experiment, were removed to the cellar on October 30th and to the greenhouse on December 15th for breeding work. These trees bloomed heavily on February 23rd and showed no sign of injury. This indicated clearly that the injury took place between October 30th and November 14th, probably on November 11th or 12th, when the temperature went respectively to 9° and 2° above zero (F.).

This early freeze was general throughout Eastern Canada, as borne out by the meteorological data obtained from observation stations in the provinces in question. The minimum temperatures for the week ending November 18th, 1933 were as follows, Kentville, Nova Scotia, 9° above zero; Fredericton, New Brunswick, 3° above zero; and Cap Rouge, Quebec 5° below zero. These early low temperatures were followed by the coldest winter on record, as shown in Table 2.

TABLE 2.—MEAN TEMPERATURES IN DEGREES FAHRENHEIT

Month	Ottawa, Ont.		Cap Rouge, Que.		Fredericton, N.B.		Kentville, N.S.	
	1933–34	45 yr. av.	1933–34	21 yr. av.	1933–34	20 yr. av.	1933–34	21 y . av.
May	55.4	54.9	51.6	50.8	50.9	51.3	51.5	49.8
June	66.2	64.7	62.7	59.5	61.2	60.6	61.6	59.9
July	68.5	68.8	65.2	65.7	65.2	66.4	64.4	65.9
August	66.2	66.2	63.8	63.0	64.6	64.1	65.7	64.4
September	60.2	58.8	56.7	55.2	57.4	56.3	57.9	57.2
October	43.6	46.3	43.8	45.1	45.3	46.3	48.9	48.5
November	20.4	32.4	23.5	31.0	26.3	32.9	29.9	36.9
December	5.1	17.4	8.1	17.2	8.6	19.2	17.7	25.3
January	10.3	12.0	9.2	10.8	8.8	14.0	16.2	19.9
February	−2.7	12.7	2.4	11.4	6.3	15.0	13.6	19.2
March	19.9	24.9	18.6	22.4	24.4	26.9	28.8	27 7
April	38.7	41.5	37.2	36.5	41.8	40.1	43.9	39.3

This abnormal cold no doubt had an aggravating effect on the already established injury and was mainly responsible for the complete killing of many trees by desiccation. Table 2 also shows why the injury was so much more severe in Eastern Ontario, Quebec and New Brunswick than in Nova Scotia, namely, because of the considerably lower mean temperature during the winter months.

Excessively dry weather during the summer of 1933, followed by a wet fall contributed in no small way to the immaturity of the wood at the entrance into winter; that is, a premature dormancy followed by a second growth. At Ottawa the precipitation for June and July in 1933 was 1.03 inches and 1.32 inches less respectively than the previous 40-year average and August showed an increase of .69 inch over the 40-year average. A true picture of this prolonged dry period is not obtained unless one considers the weekly rainfall during the month of August. Here we find that approximately two-thirds of the total rainfall occurred during the last week of the month. This abnormal rainfall in the final week of August, accompanied by an above mean temperature which continued through the month of September, aided materially in preventing the proper hardening off of the wood tissues. Somewhat similar conditions prevailed in the three eastern provinces. In New Brunswick and Nova Scotia the rainfall was abnormally high being 1.87 inches and 2.51 inches, respectively, above the 20-year average for Fredericton and 1.97 inches and 2.69 inches, respectively, above the 21-year average at Kentville. The fact that proper maturity had not been attained when winter set in was further characterized by the presence of leaves on the trees throughout the entire winter.

The determining factor in the loss in many cases was whether or not the trees had borne a heavy crop the previous year. Those which had cropped heavily died, while those without a crop survived. This again denoted lack of maturity, for it was quite evident that the trees had used up all their carbohydrates in maturing their fruit and that the accumulation of these materials in the tissues had not reached sufficient proportions to enable the trees to withstand the early low temperature.

Crotch injury was common, and on many trees limbs were completely girdled in this region, resulting in the ultimate death of that portion of the tree. The tissues composing and surrounding the crotches mature and ripen relatively slowly as compared with the other parts of the tree, thus explaining the widespread presence of this form of injury in 1933–34.

Bark splitting on the trunk caused some loss last year but was not nearly as prevalent as this year. At the present time the growers in both Ontario and Quebec are very seriously concerned about the fate of these trees. The seriousness of the injury is proportional to the degree of discoloration in the cambium region. Where the bark has become separated from the tree and is of a dark brown or walnut colour, there is little likelihood of recovery. This breaking away of the bark from the trunk seems to be associated with lack of carbohydrates in the wood tissues and is most noticeable on those trees that were badly black-hearted in 1933–34, yet bore heavy crops in the fall of 1934.

STATISTICAL STUDY OF INJURY AT OTTAWA

At the Central Experimental Farm, Ottawa, an experimental root stock orchard planted on the randomized block basis, five hundred and fifty-eight trees in all consisting of thirteen varieties of apples four years of age, afforded a splendid opportunity to analyse winter injury data on a statistical basis, particularly as to relative hardiness of the varieties. The orchard was divided into six blocks, each containing the thirteen varieties replicated three or four times on each of six root stocks. The data further lent itself to the study of the effects of the various root stocks in imparting hardiness to the top worked varieties. Each individual tree in the orchard was given a numerical value as to winter injury. This figure was termed "per cent total injury" and was determined on the following basis: a total of 20 was allocated to trunk injury, 20 crotch injury, 15 main scaffold limb injury, 20 lateral limb injury, 15 to leaf bud, and 10 to fruit bud injury.

The method of analysing the results was the same as that used by Hoblyn in the examples of field experiments in horticulture given in Technical Communication No. 2 issued by the Imperial Bureau of Fruit Production, March 1931.

The *Z* test or analysis of variance showed that the differences due to blocks and varieties were highly significant and that the odds were considerably more than a hundred to one against such differences in variance occurring by chance. The standard error test showed that the necessary difference between varieties for significant odds of 19 : 1 was 16.38% total injury. Therefore any existing difference greater than 16.38 was significant.

As already shown by the *Z* test, location was a significant factor. Blocks I and II exhibited considerably less injury than V and VI, while III and IV were mediocre. The marked severity of the injury in Blocks V and VI can readily be attributed to a low area extending across the southwest corner, thus interfering with the proper air drainage in this section of the orchard. This further shows the extreme importance of adequate air drainage on all orchard lands.

Table 3 shows the relative hardiness of the varieties used in the experiment. In this group, Lobo was hardier than all the other varieties excepting Crimson Beauty. Lawfam, Hume and McIntosh showed a similar marked degree of hardiness. The differences exhibited between Melba, Cortland, Fameuse, Diana, Linda, Wealthy, Joyce and Early McIntosh were not significant and they may be considered similar as to hardiness.

The data as to the effects of the various root stocks in imparting hardiness to the top worked varieties failed to show in a single instance a significant difference of 16.38% between any of the root stocks on a given variety. The six root stocks used were East Malling Type 2, 9, and 16, Quaker Beauty seedling, *Pyrus robusta* seedling, and French Crab. It may be concluded from the results obtained that the root stocks used in this experiment had no effect on the degree of hardiness of the tops.

It is evident from the information to date that the winter of 1933–34 was a test winter of no mean proportions and that a more thorough consideration of the problem of hardiness is essential to a continued successful fruit growing industry.

TABLE 3.—DIFFERENCE IN PER CENT TOTAL WINTER INJURY

Variety	% Total injury	Early McIntosh 97.1	Joyce 96.0	Wealthy 93.7	Linda 93.4	Diana 92.9	Fameuse 88.7
Early McIntosh	97.1	—					
Joyce	96.0	1.1	—				
Wealthy	93.7	3.4	2.3	—			
Linda	93.4	3.7	2.6	0.3	—		
Diana	92.9	4.2	3.1	0.8	0.5	—	
Fameuse	88.7	8.4	7.3	5.0	4.7	4.2	—
Cortland	83.3	13.8	12.7	10.4	10.1	9.6	5.4
Melba	82.9	14.2	13.1	10.8	10.5	10.0	5.8
McIntosh	79.9	**17.2***	16.1	13.8	13.5	13.0	8.8
Hume	75.4	**21.7**	**20.6**	**18.3**	**18.0**	**17.5**	13.3
Lawfam	74.6	**22.5**	**21.4**	**19.1**	**18.8**	**18.3**	14.1
Crimson Beauty	58.7	**38.4**	**37.3**	**35.0**	**34.7**	**34.2**	**40.0**
Lobo	55.9	**41.2**	**40.1**	**37.8**	**37.5**	**37.0**	**32.8**

Variety	Cortland 83.3	Melba 82.9	McIntosh 79.9	Hume 75.4	Lawfam 74.6	Crimson Beauty 58.7	Lobo 55.9
Early McIntosh							
Joyce							
Wealthy							
Linda							
Diana							
Fameuse							
Cortland	—						
Melba	0.4	—					
McIntosh	3.4	3.0	—				
Hume	7.9	7.5	4.5	—			
Lawfam	8.7	8.3	5.3	0.8	—		
Crimson Beauty	**24.6**	**24.2**	**21.2**	**16.7**	15.9	—	
Lobo	**37.4**	**37.0**	**24.0**	**19.5**	**18.7**	2.8	—

*Significant differences are printed in bold type.

From this costly experience much can be learned of the relative hardiness of our varieties. Since McIntosh is perhaps the best known single variety in most sections, it is cited as a standard reference. "Hardier than McIntosh" is a quality possessed to-day by few varieties of extensive commercial possibilities, though this statement does not mean that McIntosh is of first degree hardiness. As would be expected, the earlier varieties, like Crimson Beauty, Yellow Transparent, Duchess of Oldenburg, Melba and Joyce, came through with comparatively little injury on well established trees. Lobo was outstanding for hardiness in all districts and came through better than McIntosh. Lawfam seems to be of the same degree of hardiness as McIntosh, if not slightly greater. Wealthy, wherever it bore the previous summer, went out completely, and is definitely not hardy enough for further planting. Fameuse suffered heavily and was certainly not as hardy as Lobo, McIntosh and Lawfam, and as it is not a very satisfactory winter apple, may be considered to be reaching the point where it will be superseded. Cortland and Hume appear about as hardy as McIntosh. Alexander, Baldwin, Ben Davis, Delicious, Golden Russet, King, Milwaukee, Rhode Island Greening, Rome Beauty, St. Lawrence, Scarlet Pippin,

Northern Spy and Wagener all evidenced considerable killing and are definitely not hardy.

Briefly, a summary of the commercial varieties from the standpoint of hardiness reveals that Melba is still our outstanding early apple; Lobo, because of its extreme hardiness, may replace Wealthy and Fameuse; and McIntosh will continue to be the main variety. The newer winter sorts such as Lawfam and Cortland must be considered only on an experimental scale.

BREEDING NEW VARIETIES AT OTTAWA

It will be observed on close study of existing varieties that there is real need for a hardy late winter apple of high quality. In this connection the breeding project of hardy apples started in 1894 at the Central Experimental Farm, Ottawa, by the late Dr. William Saunders, then Director of the Experimental Farm System, should be considered. He first crossed the hardy Siberian crab with commercial varieties such as McIntosh, Wealthy, Duchess, etc. The resulting first crosses yielded hardy crabs thirteen to fourteen times larger than the Siberian crab mother, which is about the size of a cherry. In 1904 he selected the most promising of the first crosses and crossed them with pollen from McIntosh, Duchess, Wealthy, etc. Twenty-three per cent of these second crosses produced apples nearly fifty times as large as their Siberian grandmother and still retained the factor for hardiness. Shortly after the fruiting of these crosses Dr. Saunders retired in 1911 and died three years later. It was not until 1922 and 1923 that further steps were taken in the Saunders apple breeding project. The work was undertaken at this point by the present Dominion Horticulturist, Mr. M. B. Davis, under the direction of the late Dr. Macoun. He took the second cross varieties and gave them a third "dose" of pollen from McIntosh, Duchess, Wealthy, etc. Up to the present time 91 of the existing 615 third crosses have come into bearing. Ten of these give every indication of being of great commercial value. These promising sorts are extremely hardy as indicated by the fact that they came through the winter of 1933–34 with no sign of injury. A Duchess × Wapella cross which fruited last fall produced apples up to $3\frac{1}{4}$ inches in diameter. Several are of good eating quality and give every indication of being good keepers. Saunders' dream of large commercial apples bred from the Siberian crab has been, to a very large extent, fulfilled and it is hoped through these efforts to obtain that long overdue high quality apple of extreme hardiness.

IMPORTANCE OF HARDY FRAMEWORK

Before concluding this paper, mention should be made of the method of building a hardy framework by double working. This is a method long overlooked by the fruit growers in Canada which is of as great or even greater importance than the question of varieties.

The records at Ottawa back to 1886 as well as those from other regions in Canada with severe climatic conditions, disclose one very important fact, namely, that certain hardy Russian varieties, such as Antonovka, Anis and Charlamoff, can be grown year after year without ever losing a tree from trunk injury, crotch injury, bark splitting, sunscald, collar rot or any of the ailments to which even a good variety like McIntosh is

subject. The commercial varieties, if they themselves are reasonably hardy, when top worked to these hardy trees come through in a much better condition than on their own trunk and scaffolds. For instance, it is not uncommon at Ottawa to lose Melba and McIntosh simply because the trunk or crotch injury in the region where the main scaffolds join the trunk is so severe that the tree is injured beyond repair.

It is our firm belief at Ottawa that for many parts of Canada it would pay, in the long run, to build only trees with a hardy framework, by the following double working procedure. Only seed from the hardy Russian varieties, Antonovka, Anis, Charlamoff and *Pyrus baccata* hybrids should be used for seedling purposes. The seed is sown in the fall, say of 1935, not too thick, in rows $3\frac{1}{2}$ feet apart, in a well prepared, deep rich soil. The young seedlings which appear the following spring are dug in the fall of 1936 and lined out, in nursery rows $3\frac{1}{2}$ feet to 4 feet apart and 6 inches to 8 inches in the row. In the latter part of July or August 1937 the seedlings are budded to either Antonovka, Anis or Charlamoff. This procedure is necessary to ensure uniformity of hardiness in the trunk region. In 1938 the bud developes into a one year old whip and is ready for planting in its permanent orchard position in the spring of 1939. The tree is trained in the ordinary modified central leader type to five or six main branches, the first commencing approximately 30 inches from the ground and spaced 6 inches to 8 inches apart, arranged spirally around the trunk. As soon as these main scaffolds have reached sufficient proportions in about 1941 they are budded about 18 inches from the trunks to the standard sorts such as Melba, Lobo and McIntosh. Two of these scaffolds should be budded each year until in 1944 the entire five or six main branches are worked over, thus forming a bearing area wholly of a commercial sort.

We have now developed a tree with a hardy root stock, a hardy trunk and hardy main scaffold branches of no mean proportions. After all, no tree is any hardier than its foundation and if such a practice had been adopted in the past, we feel sure that many trees which are to-day ruined from trunk and crotch injuries would be in a flourishing condition.

We have at Ottawa other varieties of the crab type hardier than the Russian sorts, that will withstand temperatures of 50° below zero (F.) without even showing pith injury. However, they have not been tested sufficiently as yet to know whether they are satisfactory for stock purposes; that is, they may not be vigorous enough growers for varieties like McIntosh, and until we are satisfied on this score we desire to recommend only those varieties we know are satisfactory. At the present time, we favour Antonovka over Charlamoff and Anis as it appears to be slightly hardier, and also because we do know it is used for this purpose in Europe, particularly in Poland.

Résumé

Dommages causés par l'hiver dans l'est du Canada, 1933-1935. D. S. Blair, Ferme expérimentale centrale, Ottawa.

L'hiver rigoureux de 1933-34 a endommagé les pommiers dans la Nouvelle-Ecosse, le Nouveau-Brunswick, l'Ile du Prince-Edouard, le Québec et l'Ontario. La production a été réduite de 60 et de 70 pour cent respectivement dans l'Ontario et le Québec par comparaison à 1933, et de 45 et 65 pour cent respectivement par comparaison à la moyenne de cinq ans. En raison de ces fortes réductions, la pro-

duction commerciale dans l'Est du Canada en 1934 a été de 41 pour cent inférieure à celle de 1933 et de 15 pour cent au-dessous de la moyenne de 1929-33. Les plus importants des dégâts causés par l'hiver sont (1) les dommages aux bourgeons des feuilles et des fruits (2) et les dégâts aux tissus du bois au-dessus du sol. Les données recueillies établissent positivement que les gelées survenues avant le 15 novembre ont abîmé les arbres au point de causer la mort d'un grand nombre d'entre eux. L'été sec et la hauteur de pluie anormale vers la fin de l'été et le commencement de l'automne ont exercé un effet nuisible en durcissant les tissus du bois. La fente de l'écorce a été très répandue dans l'Est du Canada pendant l'hiver de 1934-35, spécialement dans l'Est de l'Ontario et du Québec. Dans la pépinière de sujets de greffe à Ottawa on a constaté des différences significatives entre treize variétés au point de vue de la rusticité, mais aucune différence apparente n'a été constatée touchant la transmission de la rusticité des sujets aux variétés greffées en tête. Les résultats montrent que la localité est un facteur significatif. Un fait se dégage bien clairement de l'examen des variétés commerciales, c'est qu'il y aurait grand besoin d'une variété tardive et rustique de pommes d'hiver de haute qualité. L'auteur appelle l'attention sur un projet de culture améliorante entrepris en 1894 à la Ferme expérimentale centrale par feu le Dr William Saunders, en quête de fruits de haute qualité et de très grande rusticité. Il donne les résultats obtenus jusqu'ici dans ce projet. Une méthode tendant au développement d'une charpente rustique par un greffage double est décrite de façon très détaillée.

Les effets de l'hiver fournissent des renseignements très précis sur la rusticité relative de nos variétés. Le pommier McIntosh qui est peut-être le mieux connu dans la plupart des secteurs, sert ici de base de comparaison. Il y a peu de variétés spécialement adaptées pour la production commerciale que l'on puisse dire plus rustiques que la McIntosh, mais ceci ne veut pas dire que la McIntosh soit du premier degré de rusticité. Comme il était à prévoir, les variétés hâtives, et notamment les Crimson Beauty, Jaune transparente, Duchesse d'Oldenburg, Melba et Joyce, n'ont que relativement peu souffert, du moins les arbres bien établis. Le Lobo s'est distingué par sa rusticité dans tous les districts et il s'est mieux comporté que le McIntosh. Le Lawfam paraît être du même degré de rusticité que le McIntosh, et même un peu plus rustique. Le Wealthy, partout où il a rapporté l'été précédent, a complètement disparu; il est certain qu'il n'est pas assez rustique pour mériter d'être planté à nouveau. Le pommier Fameuse a beaucoup souffert, il n'est certainement pas aussi rustique que les Lobo, McIntosh et Lawfam, et du reste, comme la Fameuse n'est pas une pomme d'hiver très satisfaisante, on peut considérer que cette variété est arrivée au point où elle sera supplantée. Les Cortland et Hume paraissaient être aussi rustiques que le McIntosh. Les Alexandre, Baldwin, Ben Davis, Délicieuse, Golden Russet, King, Milwaukee, Rhode Island Greening, Beauté de Rome, St-Laurent, Scarlet Pippin, Northern Spy et Wagener paraissaient tous avoir beaucoup souffert et leur rusticité laisse évidemment à désirer.

GROWTH OF FRUIT TREE STOCKS AS INFLUENCED BY A PREVIOUS CROP OF PEACH TREES[1]

W. H. Upshall[2] and G. N. Ruhnke[3]

Ontario Horticultural Experiment Station, Vineland, Ontario, and Ontario Agricultural College, Guelph, Ontario.

In July, 1927, at the Ontario Horticultural Experiment Station an experimental peach orchard which had occupied the land since 1921 was removed. Though the trees had made fairly satisfactory growth the crops of fruit had been very light. Since the fall of 1929 part of this land has been used for the production of nursery trees—apple, pear, plum, cherry and peach.

In the fall of 1931 regularly spaced alternate areas of strong and weak growth in the Mazzard cherry stock planted that spring were observed. Measurements showed that the areas of weak growth coincided almost exactly with the former locations of the peach trees in the original orchard. On digging in these areas many old decaying peach roots were found while on the other hand none were discovered in the areas of strong growing Mazzard stock. (Hereafter, the area of land on which a peach tree grew from 1921 to 1927 will be designated as the "tree" area and the space between trees as the "intervening" area.) All stocks had been budded during the month of August. In the following spring the Mazzard tops were cut off just above the bud and 25 representative tops from the tree areas and the same number from the intervening areas were weighed. The weight of the tops of the 25 plants from the tree areas was 575 grams and that of the 25 plants from the intervening areas, 1330 grams. When planted the previous spring, these two lots must have been nearly the same average size as all were No. 1 stock taken from the same shipment. Therefore it is obvious that the stocks occupying the tree areas made considerably less growth than the stocks in the intervening areas.

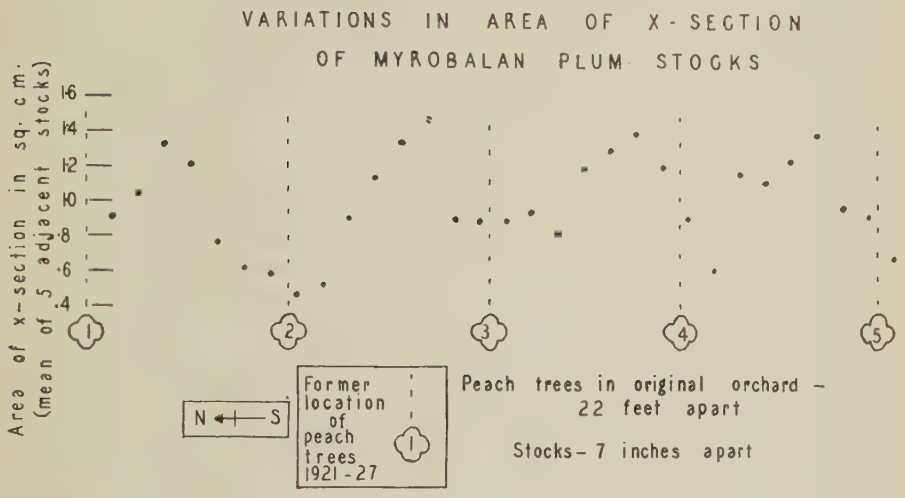
Again in 1933, on a nearby area, similar differences in growth of fruit tree stocks were observed. This time however, the effect was noted in Myrobalan plum, French pear and Mahaleb cherry stocks planted in April, 1933. Diameter measurements of each stock five centimetres above the soil surface were taken in November, 1933. The very striking differences in relative size of Myrobalan plum stocks as measured by area of cross-section computed from diameters are shown in Figure 1. Figures 2, 3 and 4 show the growth differences between tree and intervening areas that were apparent from various points near the row. The stocks were not measured at planting time but all were No. 1 size and taken from the same lot. They probably averaged about 0.6 cm. in diameter (approximately 0.3 sq. cm. in cross-section) at planting time. Assuming this estimate to be correct the stock growing in the tree areas made just about half as much new growth in 1933 as the stock growing in the intervening areas. Because of the larger and healthier leaves on the latter stock, this result was to be expected.

[1] Paper read before the annual meeting of the Horticultural Group of the C.S.T.A. at the University of Alberta, Edmonton, Alta., June 25–26, 1935.

[2] Associate in Research, Ontario Horticultural Experiment Station.

[3] Assistant Professor of Chemistry, Ontario Agricultural College.

FIGURE 1



By 1933 the old peach roots were almost completely disintegrated, and yet it was not at all difficult to mark the approximate former location of each peach tree which had been removed from the land six years before. The growth of the fruit tree stocks had been influenced to a different degree at the various points where peach trees grew (Figure 1), which can probably be explained in part by a difference in initial fertility and partly by the varying concentrations of peach roots. In a general way the farther the stocks were removed from the former locations of the peach trees the better their growth in 1933. This result was to be expected since the greatest root concentration is usually immediately adjacent to the axis of a tree, and in this area, also, the roots have been drawing on the nutrient supply for the greatest length of time.

In an endeavor to determine if possible differences in the soil character of the two areas, samples were taken for laboratory examination. Composite samples of surface soil were taken from 0–6 inches and of the subsoil from 6–12 inches from both tree and intervening areas.

There is little difference in texture of the soil between tree and intervening areas as is shown by the mechanical analysis given in Table 1.

TABLE 1.—APPROXIMATE MECHANICAL ANALYSIS. (HYDROMETER METHOD.) (SURFACE SOILS ONLY)

Sample	Sand	Silt	Clay	Colloids
Tree area	54.6	36.0	9.4	14.4
Intervening area	58.5	31.6	9.9	13.6

The relative fertility of the tree and intervening area soils is indicated by the results of the chemical examination of the samples as given in Table 2.

TABLE 2.—CHEMICAL ANALYSIS

Sample	Moisture %	Loss on ignition %	Nitrates p.p.m.	pH	Soluble phosphorus p.p.m.P.	Replaceable potassium p.p.m.K.
Tree area						
Surface	20.5	2.94	0·2	7.32	45	50
Subsoil	18.3	2.08	1.7	6.96	29	30
Intervening area						
Surface	19.0	2.83	1.5	7.10	55	56
Subsoil	19.8	2.23	1.1	6.91	38	30

The samples were taken in December, 1933. The soil from the tree areas contained slightly more moisture in the surface and slightly less moisture in the subsoil than the soil from the intervening areas. The loss on ignition values cannot be considered to be significantly different for the two soils, although the tree area subsoil has a slightly lower value than the others. Nitrates at this sampling were very low in all four samples, and the tree area surface soil was lower than the others in this constituent. In reaction, the tree area soil is slightly more alkaline in the surface and less acid in the subsoil than the intervening area soil. A difference in readily soluble phosphorus contents of tree and intervening area soils is definitely indicated by the data. Although both soils are low in this

FIGURE 2. Broad side view of Myrobalan plum stocks in tree area, Nov., 1933; x marks the place where a peach tree grew from 1921 to 1927.

FIGURE 3. Broad side view of Myrobalan plum stocks in intervening area, Nov., 1933.

FIGURE 4. Angle view of row showing Myrobalan plum stocks in tree and intervening areas, Nov., 1933; x marks the place where a peach tree grew from 1921 to 1927.

constituent, the soil from the intervening area is distinctly higher in its content of readily soluble phosphorus in both surface and subsoil. With respect to replaceable potassium the intervening area surface soil is slightly higher than the tree area surface soil but the results for the subsoil are identical. The samples had been dried and stored for almost a year before the replaceable potassium was determined and it is possible that some change in the replaceability of the potassium in the two samples could have taken place. Subsequently, samples were taken from tree and intervening areas on April 18, May 2, May 14 and May 29, 1934. Rapid microchemical tests were made on these samples by the technique of Spurway. Nitrates were higher in the intervening area surface and subsoil in April but later there was no difference in this respect. The whole area had been manured in the meantime and it is probable that previous differences in nitrate supplies in the two soils disappeared as the nitrogen in the manure became nitrified. Water-soluble phosphorus was slightly higher in the intervening area soil represented by these later samples. It is interesting to note that water-soluble potassium was distinctly higher in the intervening area surface soil than in the tree area surface soil, with the exception of the May 2nd sampling.

The results of the laboratory examination do not show marked differences in soil texture or fertility that would completely explain the difference in growth of the fruit tree stocks in the two areas. When it is considered that six years had elapsed since the peach trees were removed, it is not to be expected that initial disturbances of soil character would persist in a marked way at this time. The decomposition of peach root residues, cropping, and cultivation of the soil, during the intervening period, would tend to gradually reduce the differences. The probable depression of nitrification from the decomposition of the peach roots in the tree areas, in addition to the lowered supply of mineral nutrients (phosphorus and potassium) may have been the factors responsible for the retarded growth, first noted as typical of the tree areas.

The chemical examination of the soil failed to show very striking differences in the fertility status of the tree and intervening areas; however, field observations indicate that residual effects from occupation of land by peach trees for a period as short as six years may continue to show up in retarded growth of subsequently planted fruit tree stocks after at least a similar period of time.

Résumé

Effet d'une récolte précédente de pêchers sur la végétation des arbres fruitiers de semis. W. H. Upshall et G. N. Ruhnke.

En 1931 et de nouveau en 1933, la végétation des semis d'arbres fruitiers dans la rangée de pépinière a été plus lente qu'ailleurs dans les parties qui avaient porté des pêchers de 1921 à 1927. Un examen chimique du sol a été fait, mais aucune explication plausible de ce phénomène n'a pu être trouvée.

SOME FUNDAMENTALS OF NUTRITION OF HORTICULTURAL CROP PLANTS[1]

H. Hill[2]

Central Experimental Farm, Ottawa

In the last few years greatly increased interest has been taken in the subject of nutrition of horticultural crop plants. This has been due not only to the greater realization of the occurrence of commercial crop failure due to faulty nutrition, but also to the recognition of the fact that plants receiving a balanced nutrition are less subject to fungal and insect attack. Heck (*8*) working with sugar cane diseases states that high nitrogen conditions induce Pythium root rots; eye-spot damage is associated with low mineral assimilation, probably an unbalanced P/N or K/N ratio. Bewley (*3*) states that potassic fertilizers increase the resistance or decrease the susceptibility of the tomato plant to the bacterial stripe disease. Davidson has shown that it is possible to alter the susceptibility of the bean plant to aphis infestation.

It has been recognized that general fertilizer recommendations based on field trials, although offering a basis of fertilizer treatment for individual crops have not proven satisfactory owing to the wide diversity of conditions under which these crops are grown. It is too much to expect that, irrespective of the past fertilizer treatment, physical condition of the soil, acidity or alkalinity, and growing conditions including hours of sunlight, comparative results may be secured. Emmert and Ball (*6*) show that low moisture conditions hinder photosynthesis and the supply of carbohydrates resulting in an increase in nitrate concentration. Bewley (*3*) states that during dull weather plants require less nitrogen and more potash; potash appears to some extent to replace sunlight as a growth regulating factor. It has become necessary to consider each crop individually as far as its plant food requirements are concerned and this has necessitated some rapid method of determining plant nutritional needs.

"Appearance of plants" has been found to provide one of the most reliable indications. In 1919 Wallace in England, and a short time later the staff of the Horticultural Division at Ottawa, turned to the pot sand culture method of obtaining information which might be of assistance in understanding some of the fundamentals of plant nutrition. By growing plants in pure quartz sand and subjecting them to starvation for individual elements we have been able to obtain definite foliage characteristics which are associated with specific plant food deficiencies.

Where actual starvation of an element exists these plant symptoms of deficiencies have proven very valuable in estimating fertilizer requirements. We have also been able to obtain information regarding the necessity of nutrient balance; the importance of suitable elemental ratios, irrespective of total amount and the specific function of different food elements in maintaining the necessary nutrient balance. It is apparent that there exists a physiologically balanced nutrient solution from which the greatest

[1] Contribution from the Laboratory of Plant Physiology, Horticultural Division. Read before the annual meeting of the Horticultural Group of the C.S.T.A. at the University of Alberta, Edmonton, Alta., June 00, 1935.

[2] Assistant in Horticultural Research.

growth and yield result, and that excess as well as deficiency of a particular element may give rise to physiological disturbances. Hence, haphazard fertilizer treatments may be actually harmful since they may give rise to an unbalanced nutrient supply to the plant.

NUTRIENT BALANCE

While actual starvation or deficiency of an element may sometimes occur, trouble is often caused by a lack of nutrient balance or improper ratio of elements in the soil solution. It is a safe thing to state that it is not only the absolute amounts of different elements present in the soil that may control plant growth but also the proportionate amount of one to the other. Thus we found that concentrations of nitrogen which caused severe foliage injury to tomatoes and chrysanthemums where the potassium supply was at a certain level did not bring about such injury when the potassium level was increased, that is when the nitrogen-potassium ratio was kept constant. The injury brought about by large applications of nitrogen in the presence of the lower level of potassium might be classed as being due to either excess nitrogen or deficient potassium; in fact the symptoms are quite similar. Whether or not a certain nitrogen level is in excess depends on the available potassium supply. A suitable N/K ratio for the tomatoes and chrysanthemums in sand culture was found to be 2 to 1. Potash appears to act as the counterpart of nitrogen; where nitrogen promotes soft, sappy growth, potash on the contrary hardens growth. Russell (*10*) has summarized the relationship between potassium and nitrogen:— With a low potassium supply and large supplies of nitrogen, the uptake of nitrogen is considerable; the leaves are large but relatively inefficient owing to lack of potassium and therefore produce less carbohydrates in proportion to their nitrogen compounds. There results an abnormal excess of nitrogen in the plant which leads to various undesirable effects. Potassium is thus the counterpart of nitrogen which is associated with size of leaf.

Wallace (*11*) states. "Deficiency of one element may prevent the plant making full use of a second element, even if present in the soil in abundance and absorbed in adequate quantity. Such a close relationship appears to exist between nitrogen and potassium."

The available evidence suggests that symptoms of deficiency appearing in a plant may not only be due to a *real* deficiency of a particular element but also to an oversupply of some other element; that is to an unbalanced ratio rather than total amount available. Evidence has accumulated from various investigations which indicates that plants may absorb nutrients in approximately the same proportion that they are present in the nutrient medium, especially in the early stages of growth. Accordingly, if a particular element such as nitrogen is present in excess of the amount required for physiological balance that element may be absorbed by the plant in excess of its requirements. This luxury consumption may result in a disturbance of normal metabolism, which may seriously affect growth and yield.

MEANS OF DIAGNOSING PLANT FOOD REQUIREMENTS

In order to determine the ratio between the nutrient constituents of an added fertilizer needed to provide a balanced soil solution, a knowledge of the nutrient supplying ability of the soil is essential. Many in-

vestigations have been carried out in the past with the object of evolving laboratory tests for assessing the nutrient status of the soil. Certain of the suggested methods have been found capable of useful application, but they are still more or less empirical and are not based on precise knowledge of the availability to plants of the various forms of nitrogen, phosphorus and potassium present in the soil. Methods which appear to offer some means of success are referred to below.

Biological tests that make a direct appeal to the plant have recently been devised, prominent among which are the methods elaborated by Mitscherlich and by Neubauer. Soils have also been tested by their ability to support the growth of various micro-organisms.

In the method used at Ottawa crops are grown in soil or in sand known to be deficient in nitrogen, phosphate and potash, and the general appearance is observed. Crops showing special symptoms are considered to be lacking in particular nutrients. This system works very satisfactorily where there is actual starvation or a marked upset of nutrient balance. It does not indicate the amount of plant foods to be added to obtain maximum growth and yields.

Micro-chemical tests on the plant tissue also indicate whether the specific elements are available to the plant in poor, moderate or abundant quantities. They also serve as a check on diagnosis by plant symptoms since these sometimes may be confused with effects brought about by, environment.

SUMMARY OF FOLIAGE CHARACTERISTICS AS NOTED AT OTTAWA

Nitrogen. It is well known that general growth and vegetative development are dependent on an adequate supply of nitrogen. When the physical condition of the soil is favourable and when there is sufficient moisture a pale-green or yellow-green colour of foliage accompanied by slow growth is an indication of nitrogen starvation. The foliage may later develop reddish tints as in the case of apple foliage in the autumn. While nitrogen is the greatest limiting factor in growth, overdoses are indicated by an excessive luxuriant foliage sometimes accompanied by an imperfect development of bud, flower or fruit. The foliage is very dark green in colour, sometimes even attaining a purplish tinge and often accompanied by a marginal scorching. In cases of great excess it may also produce reduction in growth and vigour and definite injury to the foliage. In tomatoes and chrysanthemums the feeding of excess quantities of nitrogen causes the bottom leaves to first yellow around the margins. Later the yellowing increases in severity producing a mottled yellow condition, with affected leaves later scorching and dying. In the case of tomatoes the foliage injury is sometimes accompanied by brown or black streaking or lesion-like areas on the stem and petioles, resembling the disease known as streak. In tomatoes we have also found a strong correlation between feeding large amounts of nitrogen and the occurrence of the disorder known as Blossom-end Rot. We have found this trouble to be largely associated with overforcing or overfeeding of the plants, especially during short-day seasons. Allison (*1*) states that with a large supply of nitrogen a large percentage of the carbohydrates not required for respiration will go into top growth, leaving little for root growth even though the rate of photosynthesis is high. Increased leaf growth may not necessarily be accompanied by greater assimilation of carbohydrates.

Potassium. The most reliable symptom of potassium deficiency in horticultural crop plants is a yellowing of the leaf margins followed by a scorching. In the early stages this is similar to injury brought about by nitrogen excess and, as will be noted later, is a symptom of a wide nitrogen-potassium ratio. In some plants such as the strawberry, the marginal scorch is often accompanied by a purpling especially of the undersurface. In strawberries potassium deficiency is also noted by a marked flagging or wilting of the plants independent of soil moisture. Wallace (*11*) has shown that potassium deficiency in fruit trees tends to promote internal "physiological drought." He has shown that potassium deficiency is a factor contributing to leaf scorch of fruit trees. Mann (*9*) has further shown that the potassium content of leaves exerts a controlling influence on the rate of transpiration under conditions of high temperature and and bright sunshine. It would appear that potassium is a factor concerned in controlling both the up-take and loss of water by the plant. In apple foliage the scorched margin becomes ash-grey in colour. Where a complete deficiency of this element occurred tomato plants were much reduced in growth and vigour; purpling of the underside of the leaves was evidenced, while the upper surface was a muddy green. In turnips the initial stage of potassium deficiency was noted as a pin-point necrotic spotting on the leaves which was later followed by a greyish white scorch; such plants were unable to develop roots. Though large excesses of potassium were fed to tomatoes and chrysanthemums, no outward disturbances were noted although the foliage tended to be somewhat light green in colour, and in chrysanthemums a slight yellow mottling was observed. Another influence possessed by potassium which though perhaps known is not generally taken advantage of is its effect on the development of richness or deepness in bloom colour of flowering plants. We have found that heavy feeding of nitrogen or phosphorus tends to interfere with the richest development of colour, while potash encourages it. This development of colour is dependent on an adequate supply of potassium not only in total amount but in its relative concentration to nitrogen or phosphorus.

Phosphorus. An abundant phosphate supply has been shown to be particularly necessary for plants in the early stages of growth. Brenchley(*5*) has demonstrated that barley during the first six weeks of its life absorbs sufficient phosphate for full normal growth. Phosphorus deficiency is indicated by a stunting of the growth, small sized leaves dull green or greenish brown in colour which later turns to a purple or bluish purple. In some cases as in apple foliage a brownish bronze cast remains. The time of opening of flower and leaf buds is appreciably delayed.

Though excess quantities of phosphorus are not generally regarded as being harmful, in sand cultures we have obtained reduced bud formation and restricted growth and vigour with chrysanthemums. In tomatoes excess phosphorus has produced definite foliage injuries which commence as a yellowing of the leaf margins but with no sharp line of demarkation. Later fairly large white necrotic areas are formed.

Blenkinsop (*4*) working on soils in Devon and Cornwall has found that when the ratio of available phosphate to available potash approaches 10, the condition for many crops is adverse. Severe instances of leaf scorch and other indications of potash deficiency are often associated

with a high potash level masked as it were by an excessively high phosphate level.

Calcium and magnesium. In apples calcium and magnesium deficiencies produced similar symptoms, dead brown patches occurring on the margins and sometimes in the centre of the leaves designated as edge and centre blotch. Calcium deficiency was also marked by very large leaves with long petioles. In tomatoes magnesium deficiency was marked by distinctive white scorching of the leaves working inward from the margins, the scorched area having a dark brown or black line next to the still green part of the leaf. Within the affected tissue circular areas like watermarks often occurred.

CHEMICAL DATA SECURED AT OTTAWA

Analyses have been made of plant tissue produced under controlled supplies of plant food in sand cultures. With strawberries it was found that the withdrawal of potassium resulted in a marked reduction in total carbohydrates; this reduction appeared in reducing sugars, sucrose and starch. This is in agreement with Gregory (*7*) who showed that the leaves of barley insufficiently supplied with potassium contained little carbohydrate. On the other hand the omission of potassium results in an increased nitrogen accumulation. It has been shown that in potash-starved plants nitrate is not reduced and therefore protein is not formed. The importance of a balanced nitrogen-potassium ratio cannot be overstressed. Russell (*10*) states that the effect of potassium in correcting the harmful action of excess of nitrogen is in part attributable to its effect in increasing the net production of sugar and starch in the leaf, thus restoring to more normal values the carbohydrate to nitrogen ratio. In reference to ash analyses a definite antagonistic relation was found between calcium and potassium; as one falls the other tends to increase. In the plants, low potassium symptoms were obtained with excess calcium treatment. It is interesting to note that Bartholomew and Janssen (*2*) mention the possibility of the presence of excess calcium interfering with potassium intake. A negative correlation was also found between phosphorus and potassium. Deficient potassium tended to increase phosphorus accumulation and deficient phosphorus resulted in a tendency toward an increase in potassium.

REFERENCES

1. Allison, Franklin E. Carbohydrate supply as a primary factor in legume symbiosis. Soil Sci. *39* : 2. 1935.
2. Bartholomew, R. P. and George Janssen. The rate of absorption by plants and its possible effect upon the amount of potassium remaining in soils from applications of potassium fertilizers. Bull. 265, University of Arkansas.
3. Bewley, W. F. Tomatoes, cultivation, diseases, pests. Ministry of Agriculture and Fisheries, Bull. No. 77. 1934.
4. Blenkinsop, A. Soil conditions in Devon and Cornwall. Jour. Ministry of Agriculture *40* : 7 1933.
5. Brenchley, Winniferd B. The Phosphate requirement of barley at different periods of growth. Ann. Bot. (London) *43* : 169; 89-110. 1929.
6. Emmert, E. M. and F. K. Ball. The effect of soil moisture on the availability of nitrate, phosphate and potassium to the tomato plant. Soil Sci. *35* : 4. 1933.
7. Gregory, F. G. The effect of climatic conditions on the growth of barley. Ann. Bot. *40* : 1-26. 1936.
8. Heck, A. Floyd. Some indications of a relation of soil fertility and plant nutrition to cane diseases in Hawaii. Jour. Amer. Soc. of Agron. *26* : 5. 1934.
9. Mann, C. E. T. The physiology of nutrition of fruit tree. Some effects of calcium and potassium starvation. Ann. Rpt. Univ. of Bristol, Agric. and Horti. Res. Sta. 1924.

10. Russell, Edward J. Soil conditions and plant grown. Longmans, Green and Co., London. 1932.
11. Wallace, T. Leaf scorch on fruit trees. Jour. Pomol. and Hort. Sci. *6* : 4. 1928.
12. ————————. Some effects of deficiencies of essential elements on fruit trees. Ann. App. Biol. *17* : 649. 1930.

Résumé

Quelques principes fondamentaux de la nutrition des plantes horticoles. H. Hill, Ferme expérimentale centrale, Ottawa.

Il est généralement admis que si les recommandations générales d'engrais basées sur des essais en grande culture fournissent une base de traitement pour les différentes plantes, elles n'ont pas en général donné satisfaction à cause des conditions très variables dans lesquelles ces récoltes sont cultivées. Il est évident d'après les preuves expérimentales recueillies qu'il existe une solution nutritive physiologiquement équilibrée d'où l'on peut tirer la plus grande végétation et le plus gros rendement, et que l'excès aussi bien que le manque d'un certain élément peut provoquer dans la plante des troubles physiologiques qui se manifestent par des conditions anormales de végétation. Afin de déterminer la relation qui doit exister entre les principes fertilisants d'un engrais pour fournir une solution équilibrée, il est essentiel de connaître la capacité nutritive du sol. Un moyen de déterminer les principes fertilisants nécessaires est de cultiver des récoltes dans du sable de quartz pur, de les priver de certains éléments et d'obtenir ainsi certaines anomalies caractéristiques du feuillage. Ces observations peuvent être complétées par des analyses chimiques des plantes cultivées. Nous donnons ici un résumé des résultats obtenus jusqu'à date sur certaines plantes horticoles à la Ferme expérimentale centrale à Ottawa.

Azote.—On sait que la croissance générale et le développement végétatif dépendent d'une provision suffisante d'azote. Lorsque l'état physique du sol est favorable et qu'il y a suffisamment d'humidité, la couleur vert pâle ou vert jaunâtre du feuillage, accompagnée d'une végétation lente, est une indication d'un manque d'azote. Plus tard le feuillage peut développer des teintes rougeâtres comme le fait le feuillage du pommier en automne. L'azote est le plus grand facteur limitatif de croissance, mais des doses excessives d'azote sont indiquées par une luxuriance excessive du feuillage, parfois accompagnée d'un développement imparfait des bourgeons, fleurs ou fruits. Le feuillage est de couleur vert très foncé, il atteint même parfois une teinte violette, souvent accompagnée d'une brûlure marginale. Un gros excès d'azote peut aussi ralentir la végétation, affaiblir la vigueur et abîmer le feuillage. Dans les tomates et les chrysanthèmes, l'apport de quantités excessives d'azote fait jaunir les feuilles du pied autour des marges. Plus tard ce jaunissement augmente, la feuille est tachée ou marbrée de jaune; elle se dessèche à la longue et meurt. En ce qui concerne les tomates, les dégâts au feuillage sont parfois accompagnés de marbrures brunes ou noires ou de plaques en forme de lésions sur la tige et les pétioles, ressemblant à la maladie appelée marbrure. Dans les tomates nous avons trouvé également une forte corrélation entre l'apport d'une grande quantité d'azote et l'apparition de la maladie appelée "Pourriture de l'extrémité du calice". Nous avons constaté que cette maladie s'associe principalement au forçage ou au nourrissement exagéré des plantes, spécialement pendant les saisons à journées courtes.

Potassium.—Le symptôme le plus sûr du manque de potasse dans les plantes horticoles est un jaunissement du bord des feuilles, suivi par un roussissement ou brûlure. Dans les premières phases, ce symptôme est semblable à celui qui est causé par un excès d'azote et, comme nous le verrons plus tard, il dénote une large proportion relative d'azote-potassium. Dans certaines plantes, comme le fraisier, la brûlure marginale est souvent accompagnée de taches violettes, spécialement sur la sous-surface. Dans les fraisiers, le manque de potasse est caractérisé également par un fanage marqué des plantes, quelle que soit l'humidité que renferme le sol. Il semble que la potasse soit un facteur qui aide à contrôler l'absorption et la perte d'eau par les plantes. Dans le feuillage du pommier, la marge brûlée prend une couleur gris-

cendré. Lorsque cet élément faisait défaut complètement, la végétation et la vigueur des plants de tomates étaient grandement réduites; la sous-surface des feuilles se violaçait, tandis que la surface supérieure était d'un vert boueux. Chez les navets, la phase initiale du manque de potasse se signalait par une tache nécrosée en pointe d'épingle sur les feuilles, plus tard suivie d'une brûlure blanc grisâtre; ces plantes ne parvenaient pas à développer des racines. Quoique l'on ait donné un gros excès de potassium aux tomates et aux chrysanthèmes, aucun trouble extérieur n'a été noté, mais le feuillage était de couleur quelque peu vert clair, et chez les chrysanthèmes un léger barbouillage jaune a été observé. Un autre effet possédé par le potassium, qui est connu peut-être mais dont on ne profite pas généralement, est celui qu'il exerce sur le développement de la richesse ou de l'intensité de la couleur des fleurs chez les plantes à fleurs. Nous avons trouvé qu'une forte proportion d'azote et de phosphore tend à contrarier le développement de couleur le plus riche, tandis que la potasse l'encourage. Ce développement de couleur dépend d'une provision adéquate de potassium, non seulement en quantité totale, mais dans sa concentration par rapport à l'azote ou au phosphore.

Phosphore.—Il a été établi qu'une provision abondante de phosphore est spécialement nécessaire dans les premières phases de la végétation. Brenchley a démontré que pendant les six premières semaines de sa vie, l'orge absorbe suffisamment de potasse pour atteindre un développement normal complet. Le manque de phosphore est indiqué par le rabougrissement de la végétation, des feuilles petites d'un vert terne ou d'un brun verdâtre, devenant plus tard violettes ou violet bleuâtre. Dans certains cas, comme par exemple dans le feuillage des pommiers, une nuance bronze brunâtre persiste. L'époque de l'ouverture des bourgeons à fleurs et à feuilles est sensiblement retardée. Quoique des quantités excessives de phosphore ne soient pas généralement considérées comme nuisibles, nous avons obtenu, dans les cultures de sable, une formation réduite de boutons et une restriction de la végétation et de la vigueur chez les chrysanthèmes. Dans les tomates, l'excès de phosphore a produit des dégâts bien nets sur le feuillage, qui commencent sous forme de jaunissement des marges de la feuille, mais sans ligne distincte de démarcation. Il se forme plus tard d'assez grandes plaques blanches de nécrose.

Calcium et magnésium.—Chez les pommiers le manque de calcium et de magnésium produit des symptômes semblables; des plaques brunes mortes surviennent sur les marges et parfois au centre des feuilles, elles sont appelées taches des bords et du centre. Le manque de calcium se révèle également par de très grandes feuilles portant de longs pétioles. Chez les tomates le manque de magnésium a provoqué une brûlure blanche des feuilles, partant de la marge et se dirigeant vers l'intérieur, l'étendue brûlée avait une ligne noire ou brun foncé à côté de la partie encore verte de la feuille. Dans le tissu affecté, des régions circulaires comme des marques d'eau se produisaient souvent.

Données chimiques.—Il a été fait des analyses du tissu de la plante produit sous un apport réglé de principes fertilisants dans des cultures de sable. Sur les fraisiers, on a constaté que l'absence de potasse résulte en une réduction marquée de la somme totale d'hydrates de carbone; cette réduction porte sur les sucres de réduction, le sucrose et l'amidon. D'autre part, l'omission de potasse a causé une accumulation plus forte d'azote. Il a été démontré que dans les plantes privées de potasse, le nitrate n'est pas réduit et par conséquent il ne se forme pas de protéine. On ne saurait trop insister sur l'importance d'une ration équilibrée d'azote-potassium. En ce qui concerne l'analyse de la matière minérale, on a trouvé une relation antagonique bien nette entre le calcium et le potassium; lorsque l'un diminue l'autre tend à augmenter. Dans les plantes, des symptômes de manque de potassium se sont produits sous un apport excessif de calcium. Une corrélation négative a été constatée également entre le phosphore et le potassium. Le manque de potasse tend à accroître l'accumulation de phosphore et le manque de phosphore résulte en une tendance à une augmentation de la potasse.

PRELIMINARY STUDY OF THE EFFECT OF A SERIES OF TEMPERATURE CHANGES UPON RESPIRATORY ACTIVITY OF APPLES DURING THE POST-CLIMATERIC IN SENESCENT DECLINE[1]

CHARLES A. EAVES[2]

Dominion Experimental Station, Kentville, Nova Scotia

INTRODUCTION

The studies reported in this paper were conducted with a view to ascertaining the reaction of apples, as measured by respiratory activity, when subjected to temperature fluctuations particularly in relation to the temperature gradient.

The critical investigations of Blackman and Parija (*1*) must necessarily form the background to any such work. They postulate that the senescent phase of the ontogeny of the apple is characterized by what is termed as a "lowering of the organization resistance" which is represented as "an aspect of protoplasmic control of metabolic rate". They further propose that some of this hindrance to reaction is achieved by spatial separation of the reactants by impermeable protoplasmic membranes and the adsorption or combination of one or both of the reactants by the stabilised components of the protoplasm. These reactions are then related to the katabolism of the effective substrate of respiration produced by hydrolysis. The authors in their studies removed apples stored at a temperature of 2.5° C. to 22.5° C. and the respiration was increased about eight fold followed by a sharp downward drift which they term the "starvation curve." Kidd and West (*2*) however take exception to the last conclusion because they state that the consumption of CO_2 in respiration up to the time of the climacteric is five times greater at 2.5° C. than at 22.5° C.

The effects produced upon the apple by such a change of temperature have been considered by Blackman and Parija under two headings, physical and metabolic. The former is expressed as "alteration of equilibrium of solution, adsorption and loose chemical union of CO_2" and the metabolic processes divided into the "carbohydrate equilibrium effect" and the "intermediate compound effect".

The physical consideration takes into account the amount of CO_2 in the apple at different temperatures in the intercellular air spaces, that in solution in water, the CO_2 adsorbed, and that loosely held as bicarbonates, etc. Each of these phases will tend to remove the point of equilibrium upon temperature change, and a temperature rise increases the CO_2 output. The absorption coefficient for water is halved when heated from 2° C. to 22° C. and it has been found that the internal atmosphere of apples contains about five times as much CO_2 at the higher temperature, which would only make two and a half times more gas in solution at 22° C. as compared with that at 2° C. Nevertheless the apple increases CO_2 output eight times under such a change of temperature; this excess there-

[1] Paper read at the annual meeting of the Horticultural Group of the C.S.T.A. held at the University of Alberta, Edmonton, Alta., June 25–26, 1935.

[2] Graduate Student. Assisting in Storage Research. I.O.D.E. 1933 Post Graduate Scholar, Cambridge University, England.

fore cannot be attributed to solution equilibrium. Furthermore no data is available on the release of adsorbed CO_2 in the apple; thus metabolic effects are regarded as the more probable basis for this temperature effect upon respiration.

The carbohydrate equilibrium effect is the balance of starch and sugar at various temperatures and also the relationship between cane sugar and hexoses. It has been shown that the starch disappears and the hexoses accumulate whilst the concentration of cane sugar slowly decreases after picking. Account must therefore be made for the effective concentration of substrates in the apple at the time of temperature change.

Lastly the "intermediate compound effect" is concerned with all the reactants and effect of such a temperature rise upon the velocities of each reaction.

Kidd and West draw attention to the "effective concentration of enzymes" and the effective concentration of substrate as affected by the colloidal state of the protoplasm.

The nature of this experiment, however, is not such that conclusions can be drawn to throw any light upon these complex concepts of katabolism which have been briefly discussed. The conclusions drawn concerning temperature effects bear out certain findings of previous workers but as the technique used was in the nature of a trial the findings can only be regarded as tentative.

METHOD

Prior to the work undertaken as reported in this paper an investigation of the weighed tube method for determination of CO_2 output was undertaken. The two most common means of estimating CO_2 are the Pettenkofer tube method using baryta water, and the double titration method using potassium hydroxide. The former is only suitable for very slow air currents and small quantities of the gas; while the latter may be used for more rapid speeds, it is more cumbersome and thus open to greater error. The value of the weighed tube method as an alternative for respiration studies on relatively large samples was considered to be worthy of investigation. The advantage of the method is that any errors that are in the weight reading either from poor absorption or actual weighing can be immediately seen by consulting the previous readings and then re-weighed if necessary. The bleaching of the soda flake is also an indication of carbon dioxide absorption and thus there is no danger of exhausting the medium if watched carefully.

The fundamental difficulty of using soda flake as an absorption medium is that of water vapour which reduces the absorptive capacity of the flake. The water vapour moreover cannot be eliminated entirely and the condition becomes more serious as it increases in relation to the absolute concentration of carbon dioxide.

In order to study these effects a simple system using CO_2-free air was set up at 15° C. with the following types of tubes (35 cms. × 3 cms.), with cotton wool plugs and 1-hole rubber bungs at each end also with plugs placed between the soda flake and the calcium chloride.

(a) Soda flake only
(b) Soda flake + 2 cc. water
(c) Soda flake + calcium chloride
(d) Soda flake + calcium chloride + 2 cc. water

All tubes were connected in parallel in the system and the air flow regulated by a mercury manometer and a current of 3 litres per hour allowed to flow through each tube by means of calibrated capillary tubing. The air was rendered CO_2-free, being drawn through a large cylinder of soda lime (90 cms. $\times$ 5 cms.) and then dried by two tubes of the drying agent (35 cms. $\times$ 3 cms.), the first containing coarse mesh and the second fine mesh calcium chloride.

Cotton plugs were also inserted in these tubes but it was found that if the calcium chloride is packed at all closely at the entrance rapid coalesence is encountered with a resultant stoppage of the air flow.

The tubes were weighed in the room on an analytical balance twice daily and this was done by removing the rubber tubing from the glass tubing which passes through the bung at each end of the absorption tube.

The results of this test are shown in Figure 1 and the outstanding feature to be noted is the general equilibration which takes place after six days. In other words it takes that length of time in order that the outgoing air is conditioned to the same degree as the incoming air. The addition of water upsets this relationship, the loss of water vapour causing a reduction in absorption as indicated by the downward curves. The reduction however is not so marked with calcium chloride present.

The fluctuating error of the tube containing soda flake and calcium chloride (*3*) is ± 7.5 mgs. while that of the soda flake alone (*2*) is in the order of ± 9 mgs. both types being relatively stable providing minimum moisture conditions are obtained. It would appear that the lower vapour pressure of soda flake as compared with calcium chloride would therefore be an important factor in the absorption efficienty particularly in the presence of CO_2. This efficiency would be further reduced and the fluctuation error magnified greatly by increasing the rate of the air current. The drawback to using the tubes containing soda flake only is that they coalesce very quickly.

In a duplicate test the above results were corroborated, and from these findings the tube containing soda flake and calcium chloride was selected as the absorption medium for the purpose of these studies.

The fruit, Bramley's Seedling apples, was sent from the Ditton Laboratory (cellar storage) in the pre-climacteric stage of ripening; immediately upon arrival the apples were thoroughly randomised and perfect specimens selected with uniform size. They were then divided up into nine lots each weighing approximately one kilogramme (8 to 9 apples) and placed in air tight specimen jars. Three temperatures were utilised, 3° C., 10° C. and 18° C. and three lots placed at each temperature and connected to the absorption system, set up as described, in each room. Relative humidity was regulated to 75% by bubbling the air through a solution of 30% potassium hydroxide just prior to the air passing into the respiratory chamber. It may be noted that the absorption system was set up and operating three days before the arrival of the fruit and that another three days was allowed for the fruit to make the necessary metabolic readjustments to temperature conditions and the tubes to reach equilibrium. Air flow was regulated at a speeed of 2 litres per hour.

The fruit was subjected to temperature changes as indicated in Table 1.

TABLE 1.—TEMPERATURE CHANGES (IN DEGREES CENTIGRADE)

Lot No.	Initial temperature	Days				
		6	16	26	37	44
1	3° Check					
2	3	10°	18°	3°	18°	10°
3	3	18	10	3	10	18
4	10	3	18	10	18	3
5	10	18	3	10	3	18
6	10 Check					
7	18 Check					
8	18	10	3	18	3	10
9	18	3	10	18	10	3

From Table 1 it will be seen that all types of temperature changes are represented, and it was originally intended to duplicate all changes in each lot but the onset of fungal rots prevented this being done.

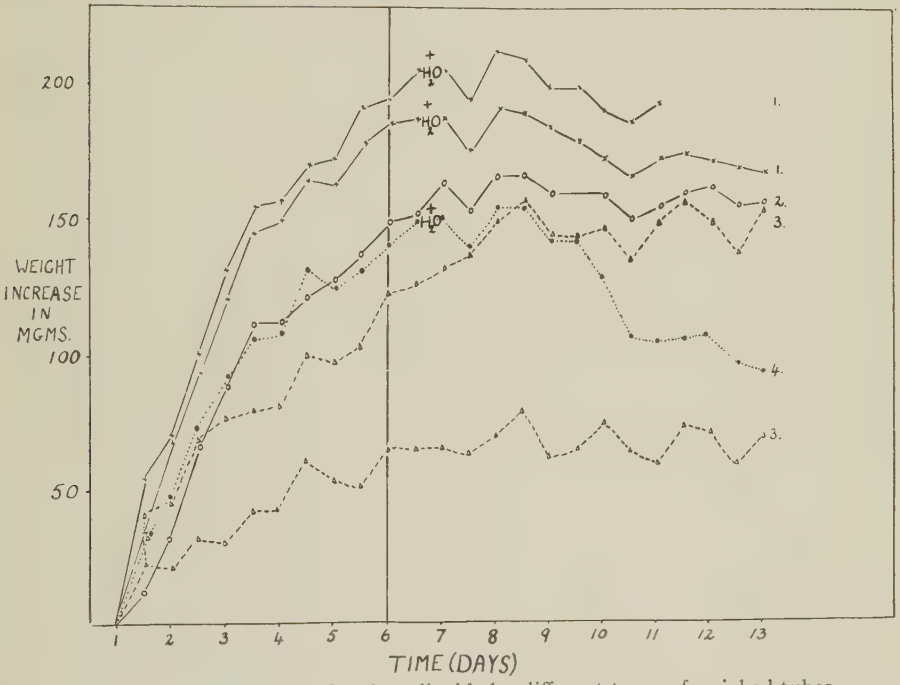


FIGURE 1. Absorption of carbon dioxide by different types of weighed tubes.
(1) $N_aOH + C_aC1_2 + H_2O$ (3) $N_aOH + C_aC1_2$
(2) N_aOH alone (4) $N_aOH + H_2O$

The tubes were weighed once a day except when temperature changes were made, when two readings were taken daily for two days after the change. The weighing was always commenced at the highest temperature in order to avoid condensation on the balance when moved from room to room and the weight was recorded to the nearest milligram. Fresh tubes were made up and placed in each room at the commencement of the experiment and these were substituted on the twenty-first day in all lots.

Very slight fungal development had begun to appear on the thirty-seventh day of the experiment in lots No. 2 and No. 4 at 3° C. and 10° C. respectively so that temperature effects beyond this point are not taken into practical consideration. CO_2 output was calculated on the basis of milligrams CO_2 per 10 kilograms of fruit per hour.

EXPERIMENTAL

Senescent drift at 3° C., 10° C. and 18° C.

In order to obtain a true picture of the relative respiratory effects upon apples subjected to sharp temperature fluctuations it is necessary first to consider the normal drift of senesence as indicated by the broken lines in Figures 2, 3 and 4. One is able to note the relative effect of temperature particularly when the respiration at 18° C. is compared with that at 3° C. In the first instance there is the sharp rise followed by a rapidly falling curve indicating a quick depletion of the effective substrate for respiration. Secondly the initial CO_2 output at 3° C. is about one-fifth of that occurring at the higher temperature; the drift in this case, however, is entirely different. The respiration increases quite slowly to a point and falls off at a much slower rate. From this curve the acceleration to the peak at 3° C. from the initial respiratory value is only one-quarter of the deceleration from the peak back to the same point. While these observations indicate that temperature greatly influences the protoplasmic control, the initial rates of acceleration cannot be used relative to deceleration from the peak because the apples were on the respiratory increase prior to the initial readings.

It is possible however to consider the onset of the climacteric at each temperature as all the applies are identical as to source and treatment. The peaks of respiration are indicated by crosses in Figure 2 on the curves representing the respiration of the checks. The ratio in number of days to reach this stage at 3° C., 10° C. and 18° C. are 2, 5 and 12 days respectively, thus bearing out previous investigations to the effect that the length of time to reach the climacteric is in inverse ratio to the temtemperature. The recent findings of Kidd and West (*3*) are worthy of note in this connection, that low temperature breakdown will develop sooner in fruit placed in cold storage at the peak of respiration than before or after that stage in the ontogenetic drift. Furthermore the deleterious effect of delayed storage may be clearly understood in the light of this pre-climacteric katabolism.

Fungal rots as related to temperature

As expected the development of moulds interfered with the respiration at the high temperature 18° C. on the twenty-seventh day, at which point the CO_2 output increased very considerably. No moulds occurred in the other checks but on the thirty-seventh day there was slight development in the lots No. 2 and No. 4; these variates were stored initially at 3° C. and 10° C. respectively but such development cannot be considered as significant in relation to the length of life, because of the inherent variation existant between members of such a small population.

Temperature co-efficients

The true effect of temperature, without consideration of other biological phenomena, can only be determined when all the fruit is uniform as soon as possible after storage. This was done by calculating the relative initial

respiratory activity of the checks. The following ratios were obtained and also the values at the peak points of each curve.

	3° C.		10° C.		18° C.
Initial	1	:	2	:	4.5
Peak	1	:	2.1	°:	4.4

It will be seen that there is a very close resemblance between these two ratios. Again an inverse of these peak ratios indicates the ratio of time taken to reach the climacteric. As the storage life proceeds the initial ratio narrows as follows:

	3°C.	10° C.	18° C.
Initial	1	2.0	4.5
26 days	1	1.86	3.0
37 days	1	1.70	2.20 (hypothetical)

Length of Life

Duration of life was found to have approximately the same relation to temperature as the CO_2 production and the figures (Figure 5) are closely correlated to those obtained by Kidd and West (*2*). The mean respiration curve was carried to zero CO_2 production and the theoretical length of life for each check lot calculated, with the results given below.

	3° C.	10°C.	18°C.
Days	217	122	61

The actual ratio does not fit in with those determined on actual CO_2 production but this may be attributed to the fact that the fall is calculated as a straight line while in reality the curve gradually flattens to a minimum respiratory value.

Influence of temperature variations upon CO_2 output.

Based on the results obtained with the checks at 3° C., 10° C. and 18° C. it is to be expected that the metabolic drift will be considerably affected by a variety of temperature experiences. Protoplasmic readjustments will take place either depressing or stimulating the organization resistance with subsequent increase or decrease of the effective substrate of respiratory activity.

There are one or two preliminary considerations that should be noted. The curves in Figures 2, 3 and 4 are shown as the general mean, but the figures given for CO_2 output have been calculated from the original readings except where otherwise stated. In order to obtain a more detailed picture of the change of respiration from one temperature to another half hour readings were taken on two lots for twenty-four hours. The change is expressed in Figure 6 as the increase

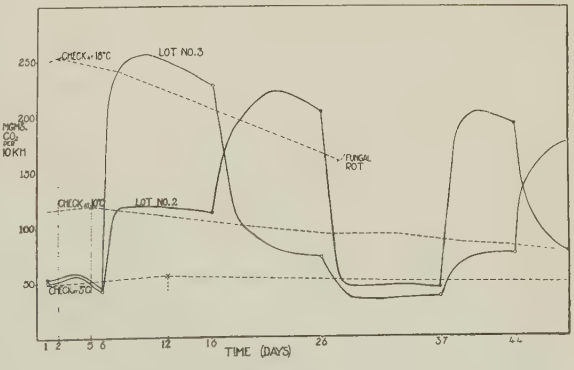


FIGURE 2. Respiratory activity of Bramley's Seedling apples as affected by change of temperature in storage (3° variates).

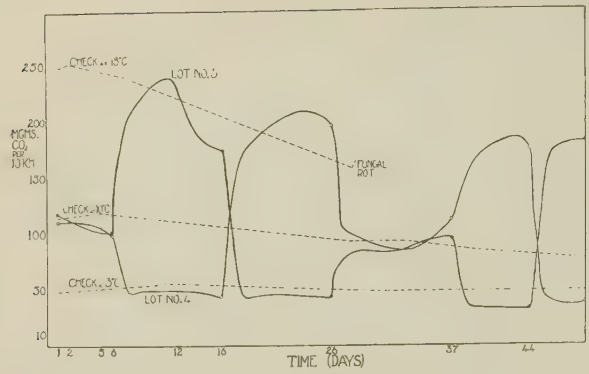


FIGURE 3. Respiratory activity of Bramley's Seedling apples as affected by change of temperature in storage (10° variates).

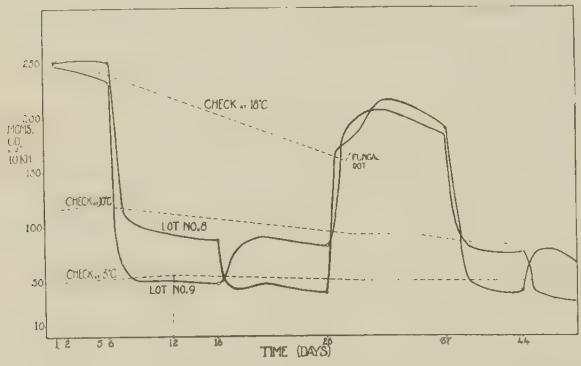


FIGURE 4. Respiratory activity of Bramley's Seedling apples as affected by change of temperature in storage (18° variates).

or decrease of gain in weight of the weighed tubes. The vertical lines indicate the immediate change from the initial to the final temperatures. The check lots at 3° C. and 10° C. were used for this purpose at the end of the experiment, and were both moved up to 18° C. Both curves show a flattening out at the end of twenty-four hours although the 3° C. to 18° C. still have a slight upward tendency. The initial reactions of these lots indicate that the reaction of the 10° C. fruit to exposure at higher temperatures is greater than the 3° C. fruit. Unfortunately all the temperature changes were not followed as closely in the course of the experiment.

Analyses of the respiratory curves of the temperature variates in relation to the check lots will now be made. First in order to avoid confusion the two variates from each temperature will be dealt with in pairs in the order of 3° C., 10° C. and 18° C.

The increases or decrease of total CO_2 output of the variate in relation to the checks has been calculated over three periods of temperature change. For example Lot 2 was removed from 3° C. to 10° C. and remained at the latter temperature for 10 days, the total CO_2 output being measured during that period both for Lot 2 and the 10° C. check and the difference found; in this case Lot No. 2 exceeded the check by 150 mgs. The next move was from 10° C. to

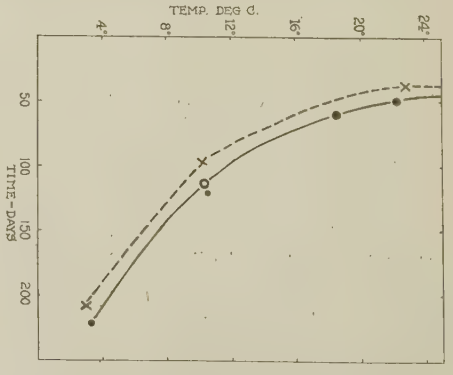


FIGURE 5. Relative length of life of apples in terms of CO_2 production stored at 3° C., 10° C. and 18° C. (Dotted line represents observations of Kidd and West.)

18° C.; again Lot No. 2 was in excess of the 18° C. check by 260 mgs. CO_2. When removed back to 3° C. this same lot showed lower output than the 3° C. check, indicating that the temperature experience was unfavorable relative to the check. This data for each variate is condensed in Table 2.

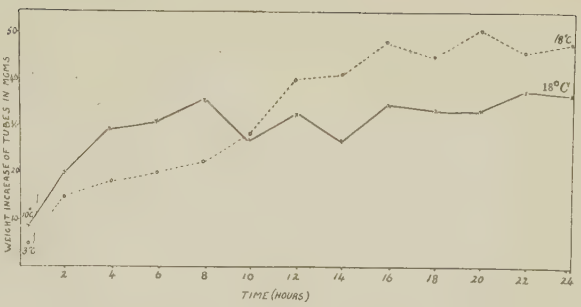


FIGURE 6. Progress curve of increased respiration of apples placed at 18° C. removed from 3° C. and 10° C. (Expressed as weight increase of tubes.)

TABLE 2.—INCREASE OR DECREASE OF CO_2 OUTPUT OF TEMPERATURE VARIATES (DEG. C.) IN RELATION TO CHECKS OVER 10 DAY PERIODS (BRAMLEY'S SEEDLING APPLES)

Lot no.	Initial temp.	Relative CO_2 output in mgms. of variates to checks at each temperature for 10 days		
2	3°	10° +150	18° +260	3° −50
3	3°	18° +210	10° +330	3° −110
4	10°	3° −60	18° +170	10° −10
5	10°	18° −60	3° −60	10° −50
8	18°	10° −170	3° −90	18° +600
9	18°	3° −60	10° −110	18° +440

The differences between CO_2 output of the variates from the extreme temperature checks are much greater than that at the mean temperature of 10° C.; this is particularly true of those from 18° C. Account must be taken of the respective respiratory drifts of each of the checks in consideration of Table 2.

Lot No. 3 with a sharp initial gradient to 18° C. brings about a heavy depletion of effective substrate which reduction is apparently carried through during the mean temperature experience. The gradual rise to the high point by Lot No. 2 on the other hand is more favorable as will be seen from the figures for the final period when both lots were returned to the original temperature. The variates from 10° C. are relatively uniform but the CO_2 output during the last period would point to the stimulating effect produced upon the living activities by high temperatures in the early stages as shown by Lot No. 4.

The variates from 18° C., which had passed through the climateric before they were moved to the lower temperatures, exhibit very definite signs of lower resources when compared with the respiratory activity of the check at 3° C. and 10° C. In all four periods at these temperatures the variates produce less CO_2 than do the checks. During the last period the figures are based on a theoretical check, the steep initial gradient of Lot No. 9 from 18° C. to 3° C.; has an apparent effect in reducing the rate of respiration throughout the whole series of temperature changes.

When all the variates are considered together it is seen that all downward temperature fluctuations are characterized by negative relationships to the checks, in other words there is an excessive depression in the respiratory rate. Upward fluctuations are mostly positive in character except in three instances, two of which are temperature changes from 3° C. to 10° C. (the only other 3° C. to 10° C. change was initial). These particular changes are preceded by a sharp drop from 18° C. which again supports the observation that the effectiveness of the substrate is reduced by high temperature experience in the early storage life. Again it is seen from Table 2 that the sharper the initial change, the more depressed is the output in the last period; and lastly all variates except those from 18° C. register a lower output at the final temperature than do the corresponding checks.

To further ascertain the quantitative relationship of these temperature variates a factor was determined for increase or decrease of respiratory activity by dividing the value for respiratory activity (R.A.) before the change in temperature with the maximum value after the change. For example let the R.A. at 3° C. be 50 mgs. per K.H. and this output rises to 100 mgs. per K.H. at 10° C. then the R.A. factor is 2. Reversing the process the factor then becomes 0.5; in order, however, that the factors for upward and downward changes are to be comparable the reciprocal is used, which is 2 in this case. These factors are shown in Table 3, and the figures in parenthesis indicate which of the three temperature changes is involved.

Table 3.—Factors for increase or decrease of respiratory activity oh change of temperature (Bramley's Seedling apples)

Lot No.	Temperature change, Deg. C.					
	10°–18°	18°–10°	10°–3°	3°–10°	3°–18°	18°–3°
2	1.85(2)	...	...	2.65(1)	...	4.48(3)
3	...	3.10(2)	2.10(3)	...	5.86(1)	...
4	...	2.33(3)	2.08(1)	...	5.30(2)	...
5	2.34(1)	...	...	2.00(3)	...	4.00(2)
8	...	2.86(1)	2.20(2)	...	5.35(3)	...
9	2.53(3)	...	...	1.90(2)	...	4.85(1)

From Table 3 it may be noted that the R.A. factors increase in value with the range of temperature. The factors representing seven or eight degrees in range are characterized by uniformity except the 18° C. to 10° C. changes which are somewhat higher, possibly showing a greater degree of respiratory depression for this particular change. There is a consistently higher factor for the 3° C. to 18° C. temperature change as

compared with the 18° C. to 3° C. indicating that the stimulation effect exceeds the repressing effect upon CO_2 output. The actual difference between these effects could only be considered however in the light of the general metabolic drift; nevertheless the sum of the R.A. factors for upward changes throughout the experiment are in excess of the sum of these factors representing downward changes.

Gain or loss in length of life as affected by temperature variations

Assuming that the CO_2 output may be used as an index of the metabolic activities of the fruit, the total amount respired by each lot over a period of 35 days has been determined in order to arrive at the relative effects upon the length of life by temperature change. The 35 days included the first five days at the initial temperatures and three ten-day periods following. These totals are shown in Table 4 in descending order of magnitude.

The check at 18° which was removed on the twenty-seventh day had up to that time a total CO_2 output of 5285 mgs., which considerably exceeds all other respiratory values based on 35 days. However the figure for 35 days was obtained theoretically by continuing the curve from the point where fungal rot developed. Using the above totals as a basis for gain or loss in length of life over a 35-day period the R.L. (relative length of life) was determined and is graphically represented in Figure 7. The R.L. of the variates are considered separately for each temperature and based on the actual CO_2 production of each check over 35 days (solid columns). The R.L. of the checks are shown as broken columns A, B and C, and are based on the actual CO_2 production at 3° C.

TABLE 4.—TOTAL PRODUCTION OF CO_2 IN 35 DAYS (BRAMLEY'S SEEDLING APPLES SUBJECTED TO A SERIES OF TEMPERATURE CHANGES)

Lot No.	Temperature changes, Deg. C.	Total production mgs. CO_2 (35 days)
7	Check at 18°	6652
8	18°–10°– 3°–18°	4642
9	18°– 3°–10°–18°	4587
3	3°–18°–10°– 3°	4454
2	3°–10°–18°– 3°	4147
5	10°– 3°–18°–10°	4079
4	10°–18°– 3°–10°	4000
6	Check at 10°	3642
1	Check at 3°	1907

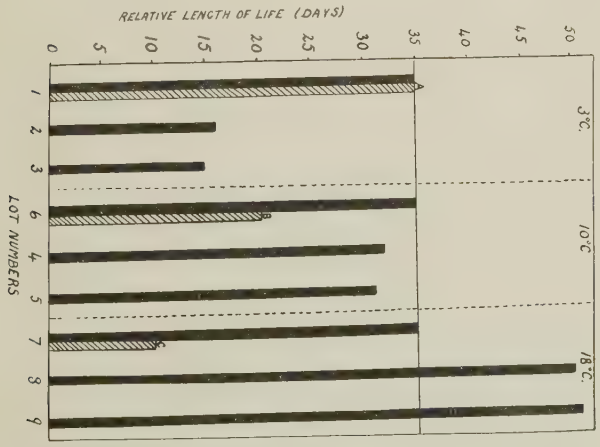


FIGURE 7. Gain or loss of length of life in terms of CO_2 production over 35 days as affected by temperature variations.

The R.L. of the 18° C. variates is in inverse ratio to those at 3° C., but not proportionate, in that the gain of Lots 8 and 9 are 15 and 16 days respectively over the 18° C. check, whilst there is a loss of 20.2 and 19.0 days for Lots 2 and 3. It is again shown that the sharp changes in the initial storage life in Lot No. 3 (3° C. to 18° C.) is more unfavourable than the slower gradient as in Lot 2 (3° C.–10° C.–18° C.). The reverse is true of Lot 8 (18° C.–10° C.–3° C.) and Lot 9 (18° C.–3° C.). The variates from 10° C. also indicate that apples moved to a high temperature initially have their length of life reduced, in that Lot 5 (10° C.–18° C.) is less than lot 4 (10° C.–3° C.). Furthermore the R.L. of Lots 2 and 3 exhibit a greater decrease than that shown by the check at 10° C. from which it may be concluded that although the 3° C. variates received actually a longer low temperature experience than the 10° C. check, the fruit failed to recover from the short period of storage at the high temperature (18° C.) which apparently brought about a lowering of the organization resistance.

Finally the relation between the checks A (3° C.), B (10° C.) and C (18° C.) is clearly shown, but it must be understood that there is no basis for comparison of B and C with the variates from 10° C. and 18° C.

SUMMARY

1. The weighed tube method of estimating CO_2 in a moving air stream was investigated and as a result this technique was used in the experiment reported. The results of the experiment indicate that this method is applicable for respiratory studies upon relatively large samples of apples.

2. The effect of temperature upon the metabolic drift of Bramley's seedling apples during the senescent phase was studied. Respiratory activity of the check lots stored at 3° C., 10° C. and 18° C. was characterized by a rise in CO_2 output to the climacteric followed by a decline. The length of life of the apple and the onset of the climacteric in terms of CO_2 output are in an inverse ratio to the rise in temperature.

3. The onset of fungal invasion causes a rise in the curve of respiration.

4. The effect of a series of temperature changes upon the fruit is influenced by the gradient of change and the time of the change. Sharp initial upward temperature gradients 3° C.–18° C. resulted in a heavy depletion of effective substrate as shown by excessive lowering of respiratory activity. The sharp downward gradient initially, reduced subsequent respiratory activity. The gain in relative length of life of the 18° C. variates was found to be higher in proportion to the loss suffered by the 3° C. variates. Results showed that a mean steady temperature of 10° C. tended to be more favorable to the life of the apple than did sharp upward temperature fluctuations from 3° C. although the fruit was stored longest at that temperature.

ACKNOWLEDGMENTS

As the holder of the 1933 Post graduate Overseas War Memorial Scholarship sponsored by the Imperial Order Daughters of the Empire, the author wishes to express his gratitude to the Order for the opportunity of pursuing these and other studies for one year at the Low Temperature Research Station, Cambridge, England. Thanks are also due to the staff of the above station for help and assistance at all times.

REFERENCES

1. Blackman, F. F. and P. Parija. Analytic studies in plant respiration. Proc. Roy. Soc. Series B. *103* : 412-523. 1928.

2. Kidd, F. and C. West. Physiology of fruit Part 1, Changes in respiratory activity of apples during their senescence at different temperatures. Proc. Roy. Soc. Series B, *106* : 93-109. 1930.

3. ———————. The causes of low temperature breakdown in apples. F.I.B. Rept. Great Britain : 57-60. 1933.

Résumé

Etude préliminaire de l'effet d'une série de changements de température sur l'activité respiratoire des pommes. Charles A. Eaves, Station expérimentale fédérale, Kentville, N.-E.

Il est fait rapport dans cet article d'une évaluation de la méthode de tubes pesés pour la détermination du CO_2 dans un courant d'air en circulation. Un tube d'absorption contenant des écailles de soude et du chlorure de calcium a été choisi pour les fins de cette expérience. L'introduction à ce travail présente les hypothèses de Blackman et Parija, ainsi que de Kidd et West, sur la période de sénescence dans l'évolution ontogénétique de la pomme. L'effet d'un certain nombre de changements de température sur la respiration des pommes Bramley's Seedling est indiqué et comparé à l'effet noté sur celles qui avaient été conservées continuellement à chacune de trois températures, 3° C., 10° C., et 18° C. La discussion traite du début du maximum de la respiration à ces trois températures et de la durée relative de la vie, basée sur la production de CO_2 pour toutes les quantités de fruits employées dans l'expérience. Il a été constaté que l'élévation de température est en relation inverse de la durée de la vie de la pomme dans les lots témoins. De fortes élévations de température dans la première phase de la conservation en entrepôt paraissaient être accompagnées d'une déplétion rapide de la couche inférieure active, indiquée par une diminution excessive de l'activité respiratoire. Les résultats indiquent qu'une température moyenne constante de 10° C., est plus favorable à la vie des pommes que de brusques fluctuations à partir de 3° C., quoique les fruits aient été entreposés plus longtemps à cette température. Enfin, la courbe du changement de température a produit des effets marqués sur l'évolution de CO_2 pendant la période à l'étude.

THE SASKATCHEWAN LAND UTILIZATION ACT, 1935

Purpose.—The purpose of this Act is to regulate the utilization of certain lands deemed to be unsuitable for agricultural purposes.

Administration.—The Act provides for a Land Utilization Board consisting of a member of the Local Government Board, the Professor of Farm Management, University of Saskatchewan, the Deputy Minister of Agriculture, the Deputy Minister of Municipal Affairs and the Deputy Minister of Natural Resources.

Regulated Areas.—The Lieutenant Governor in Council may from time to time declare that any specified area of the province shall be an area for purposes of this Act.

Powers.—The Board may proclaim any land within a regulated area to be unsuitable for agricultural purposes, such land, thereafter to be "public lands". Provincial lands may be declared to be unsuitable for agriculture only with the written consent of the Minister of Natural Resources.

The Lieutenant Governor in Council may direct that any "public lands" shall be dealt with in such a manner as appears to be advisable for the benefit of the residents of the area in which such lands are situated; close up road allowances within an area; make adjustments in the taxes on such land; provide for the dissolution of any rural municipality within a regulated area and exercise all of the powers and duties of the council of such municipality; arrange for the payment of the debenture indebtedness of any school district within a regulated area from the revenues from leases granted under the authority of this Act, and generally do all such things as may be deemed necessary or advisable for carrying out the purposes of this Act.

It is also provided that the Lieutenant Governor in Council may delegate to the Board certain of the above powers. In addition to such delegated powers, the Board may lease "public lands" at such rentals, including taxes, as may be deemed advisable; receive moneys payable by lessees of "public lands" and expend any part of same for the betterment of the area in which such lands are situated; set aside any "public lands" for the purpose of community grazing and regulate the use of such land; exchange for lands within a regulated area any other lands whether within a regulated area or not.

Land acquired within a regulated area by a rural municipality under the provisions of the Arrears of Taxes Act may not be disposed of without previous consent of the Board. Such consent shall not be given in respect of "public lands."

Payment of outstanding taxes on lands which have become "public lands" may be made from any revenue derived from such lands after providing for the proper proportion of the expenses of administration and development of the area. The Board is further authorized to make regulations not inconsistent with the spirit of the Act for the purpose of carrying out its provisions and supplying any deficiency therein.

It was provided that the Act should come into force on a date to be named by proclamation of the Lieutenant Governor.

THE ECONOMIC ANNALIST

A REVIEW OF AGRICULTURAL BUSINESS PREPARED QUARTERLY BY THE AGRICULTURAL ECONOMICS BRANCH, DEPARTMENT OF AGRICULTURE, OTTAWA

Vol. V, No. 3 September, 1935

THE ECONOMIC SITUATION

PREPARED IN THE AGRICULTURAL ECONOMICS BRANCH, DEPARTMENT OF AGRICULTURE, OTTAWA, FROM BASIC DATA COLLECTED BY THE DOMINION BUREAU OF STATISTICS

Stability in wholesale prices was reflected in the index number of wholesale prices in Canada which was unchanged in July. There were fractional gains in prices of vegetable products; animals and their products; fibres, textiles and textile products; wood, wood products and paper; non-ferrous metals and their products; and non-metallic minerals and their products. Small losses were registered in iron and its products, and chemicals and allied products showed no change.

Retail Prices.—The index of retail prices, rents and costs of services was also unchanged and among the sub-indexes only one slight change was reported, the index of prices of sundries receding two-tenths of a point. Minor revisions in the monthly indexes have been made as a result of more complete data.

Physical Volume of Business.—The index of the physical volume of business almost regained the high point of 103.2 recorded in May. Industrial production advanced from 99.7 to 104.0. Mineral production was just slightly above the level reached in June, the index being 135.3. Exports of nickel and zinc were higher. Shipments of gold and silver were lower. Imports of bauxite were much higher and coal production showed a gain. The index of manufacturing was substantially above that for June, rising from 98.4 to 101.7. Production of food stuffs made a slight gain. Exports of cheese rose from 48.8 to 127.7. The index of tobacco releases was slightly lower. Imports of textiles showed as a whole a sharp advance. Forest products were at about the same level as in June. Newsprint was decidedly lower but exports of boards and planks and shingles were higher than in June. Iron and steel production was substantially above that for June, the index rising from 107.4 to 142.8. Construction made a reasonably good gain, contracts awarded rising nearly twenty points. Trade employment was slightly improved. Car loadings made a small gain. Both exports and imports were higher than in June.

Marketings of grains and live stock were above those in the previous month, the index advancing from 106.1 to 164.7. Larger shipments of wheat and oats were chiefly responsible for the rise in grain marketings. Marketings of cattle and hogs showed substantial increases but the movement of sheep was less than during the month of June.

The index of cold storage holdings in July was considerably lower than in June. Stocks of eggs, butter, cheese, beef, pork and lard were below those in June. There was an increase in holdings of veal, poultry and mutton.

Agricultural Products.—The index of wholesale prices of Canadian farm products was substantially unchanged, the index in July being 61.5 compared with 61.4 in June. The average price of No. 1 Manitoba northern wheat basis Fort William and Port Arthur was 81.4 cents per bushel compared with 81.7 in June. No. 2 C.W. oats were 42.9 cents as against 39.8 in June, No. 2 C. W. rye 36.1 cents and 41.2 cents respectively, and No. 3 C. W. barley 35.5 cents compared with 39.2 in June. The average price of No. 1 C. W. flax was 122.6 cents in July whereas in June, it was 121.4.

1923—4

ANNUAL AND MONTHLY INDEX NUMBERS OF PRICES AND PRODUCTION COMPUTED BY DOMINION BUREAU OF STATISTICS

Year	Wholesale Prices 1926 = 100				Retail prices and cost of services (5)	Production (6) 1926 = 100			
	All commodities (1)	Farm products (2)	Field products (3)	Animal products (4)		Physical volume of business	Industrial production	Agricultural marketings	Cold Storage holdings
1913	64.0	62.6	56.4	77.0	65.4				
1914	65.5	69.2	64.9	79.0	66.0				
1915	70.4	77.7	76.9	79.2	67.3				
1916	84.3	89.7	88.4	92.3	72.5				
1917	114.3	130.0	134.3	119.6	85.6				
1918	127.4	132.9	132.0	134.7	97.4				
1919	134.0	145.5	142.4	152.5	107.2	71.3	65.5	48.1	47.1
1920	155.9	161.6	166.5	149.9	124.2	75.0	69.9	52.6	94.2
1921	110.0	102.8	100.3	108.5	109.2	66.5	60.4	65.2	86.4
1922	97.3	86.7	81.3	99.1	100.0	79.1	76.9	82.6	82.8
1923	98.0	79.8	73.3	95.1	100.0	85.5	83.8	91.4	87.6
1924	99.4	87.0	82.6	97.2	98.0	84.6	82.4	102.5	114.9
1925	102.6	100.4	98.1	105.7	99.3	90.9	89.7	97.2	108.6
1926	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1927	97.7	102.1	99.9	105.7	98.4	106.1	105.6	103.6	110.0
1928	96.4	100.7	92.6	114.3	98.9	117.3	117.8	146.7	112.8
1929	95.6	100.8	93.8	112.5	99.9	125.5	127.4	101.1	109.6
1930	86.6	82.3	70.0	102.9	99.2	109.5	108.0	103.0	128.4
1931	72.2	56.3	43.6	77.6	89.6	93.5	90.4	99.0	125.7
1932	66.7	48.4	41.1	60.7	81.4	78.7	74.0	114.3	120.1
1933	67.1	51.0	45.8	59.6	77.7	79.7	76.8	105.1	115.4
1934	71.6	59.0	53.9	67.6	78.9	94.2	93.6	88.5	114.2
1934									
Jan.	70.6	55.3	47.9	67.8	78.2	86.8	84.5	48.2	108.1
Feb.	72.1	58.0	49.3	72.5	78.7	86.4	84.0	67.1	98.6
Mar.	72.0	56.5	49.5	68.3	79.9	93.1	92.0	63.8	97.0
Apr.	71.1	55.4	48.7	66.6	79.4	92.6	91.4	56.9	94.5
May	71.1	56.9	51.1	66.5	78.5	99.6	99.4	130.6	102.6
June	72.1	59.3	55.5	65.6	78.2	95.8	95.2	97.2	126.1
July	72.0	60.0	57.8	63.7	78.4	95.7	95.6	148.8	116.3
Aug.	72.3	61.6	60.7	63.1	78.7	99.0	99.8	172.8	114.7
Sept.	72.0	61.3	58.9	65.3	79.0	97.1	97.5	127.7	117.7
Oct.	71.4	60.9	55.3	70.4	79.3	95.8	95.3	61.2	128.8
Nov.	71.2	61.2	55.7	70.4	79.4	96.5	97.0	51.2	130.4
Dec.	71.2	61.6	56.0	70.9	79.0	92.4	91.0	36.0	135.7
1935									
Jan.	71.5	61.4	55.7	71.0	78.8	97.5	97.8	30.6	143.7
Feb.	71.9	62.0	55.7	72.6	78.9	100.6	101.1	62.2	141.2
Mar.	72.0	62.7	56.4	73.3	78.8	94.2	93.3	65.4	143.2
Apr.	72.5	64.7	59.8	72.9	78.6	98.3	97.7	91.8	135.8
May	72.3	64.1	58.0	74.4	78.7	103.2	101.4	86.3	123.2
June	71.5	61.4	55.1	72.0	78.8	99.2	99.7	106.1	125.0
July	71.5	61.5	55.7	71.1	78.8	103.0	104.0	164.7	114.8

1. See Prices and Price Indexes 1913-1928, pp. 19-21, 270-289 and 1913-1932, p. 15.
2. Wholesale prices of Canadian products of farm origin only. See Prices and Price Indexes 1913-1932, p. 32, and Monthly Mimeographs 1933 and 1934.
3. Wholesale prices of grains, fruits and vegetables.
4. Wholesale prices of Animals and Animal Products.
5. Including foods, rents, fuel, clothing and sundries, See Prices and Price Indexes 1913-1928, pp. 181-185, 290-293. 1926 = 100.
Prices and Price Indexes 1913-1931, p. 122, and Monthly Mimeographs, 1933-1934.
6. Monthly Review of Business Statistics, p. 8, and Monthly Indexes of the Physical Volume of Business in Canada, supplement to the Monthly Review of Business Statistics, November, 1932.

The carryover of wheat at the end of the crop year was 214,935,824 compared with 203,944,533 bushels at July 31, 1934. Exports during the past crop year were 144,374,910 bushels compared with 170,234,013 in 1933–34. Exports of wheat flour

were 4,750,310 barrels compared with 5,454,636 barrels in the crop year of 1933–34. The world carryover at July 31 was 850 million bushels compared with 1,135 million in 1934.

The index of prices of live stock and animal products receded still further, being 71.1 in July, prices of steers, calves, sheep and hogs all being lower at Toronto and Winnipeg. Prices of creamery butter in Toronto and Montreal were lower than in June but above the average for July 1934.

Dairy Products.—The quantity of cheese graded between December 3, 1934 and July 27, 1935 was 394,642 boxes, compared with 439,913 in the period December 4, 1933 to July 29, 1934.

Butter production in Canada during the first six months of 1935 showed a decrease of 5% compared with 1934. Quebec was the only province in which an increase was shown and this amounted to 3.4%. Production in Ontario declined .04%. Marked decreases have taken place in the Maritime Provinces, Manitoba and Alberta.

Live Stock Marketing.—Sales of cattle at public yards during the first thirty-four weeks in 1935 were 439,335 head compared with 387,215 during the same period in 1934. Sales of calves were 258,883 and 239,549 head respectively. There were 187,896 sheep sold during this period of 1935 as against 192,652 in 1934. The number of hogs graded was 1,903,544 and 1,958,642 respectively.

Prices in United States.—Wholesale prices in the United States have fluctuated about two points during the first six months of the year. The index was 115 in January and rose to 117 in April and receded to 116 in June. The index number of farm prices (August 1909–July 1914 = 100) fell from 104 in June to 102 in July. The decline was general but was most marked in the case of grains, truck crops, dairy products and meat animals.

COST OF MANUFACTURING BUTTER IN THE PRAIRIE PROVINCES[1]

C. V. Parker[2]

The production of creamery butter in the three Prairie Provinces was 67,148,500 pounds in 1934. This was 28.8% of the total production of the Dominion for that year. Production in the three provinces in 1934 was two and one-half times that of 1920, while the output of the Dominion was about double that of 1920. Butter production in the West has thus been increasing at a faster rate than the output of the whole Dominion. Particularly has this been so over the past five years.

More butter is produced in the three Prairie Provinces than is consumed there. The surplus is shipped to Eastern Canada and to British Columbia, and a small portion is exported to other countries.

Economy in the production of a commodity is always important and it is much more so when, as in the case of butter in the Prairie Provinces, a large proportion is shipped to distant markets. A knowledge of the factors affecting cost is, therefore, necessary in order that the most economical practices may be adopted. It was for this reason that a study of creamery management was instigated.

The study was conducted jointly by the Dairy Branch of the Departments of Agriculture in the three Prairie Provinces, the Rural Economics Divisions of the Universities in the Provinces and the Dairy and Economics Branches of the Dominion Department of Agriculture. Records from 91 of the 210 creameries operating in 1933 were obtained by personal visit to the creameries. Only 78 of those secured have been used for tabulation purposes. The records cover the 1933 fiscal year of the companies and they were obtained in the fall of 1934. The following data, comprising but a part of the study, deals with the costs of manufacturing butter and of gathering cream, and the returns to creameries and producers.

Cost of Manufacturing.—In this study, the cost of manufacturing a pound of butter includes all items of cost from the time the cream is received at the creamery until the butter is packed into 56-pound boxes. Charges for gathering the cream (dealt with in a succeeding paragraph) and costs of printing and shipping the butter are, therefore, excluded. Commissions on cream cheques have also been omitted.

[1] Preliminary, subject to revision. Final, more detailed report to be issued later.
[2] Assistant Agricultural Economist, Economics Branch, Department of Agriculture, Ottawa.

Details on costs presented below were obtained from factory statements and with the exception of a few items were not changed. It was necessary to set up a uniform method of charging off depreciation because practices varied so widely. In this study, depreciation on equipment was calculated on the year's future use basis; present values and year's future use were obtained for the major items of equipment; by dividing the years into the present value, a depreciation figure for the year of the study was obtained. Depreciation on frame buildings was charged at 5 per cent and on brick structure at 3 per cent of the present value. The sum total of all depreciation charged corresponds closely to the amount allowed by the companies. Interest on investment has been included as a cost and was charged at 6% of the present value of that portion of land, buildings and equipment used in the manufacture of butter.

In Table 1, the 78 factories included in the study are grouped according to the pounds of butter manufactured. The average cost of manufacture in plants in which the production was under 100,000 pounds of butter for the year was 4.82 cents per pound while in factories having an output of over 500,000 pounds, the figure was 3.18, a range of 1.64 cents per pound. The effect of increased volume on unit cost is well illustrated in this table. The range in cost from the lowest to the highest cost factory was from 2.62 to 6.56 cents, a difference of 3.94 cents per pound.

An examination of the individual items of expense reveals the items which are affected when volume is increased. For instance, plant wages decreased from 1.36 cents per pound butter in very small plants to 0.76 cents in the largest factory group.

TABLE 1.—THE RELATION OF VOLUME OF OUTPUT TO COST OF MANUFACTURING A POUND OF BUTTER IN 78 CREAMERIES, PRAIRIE PROVINCES, 1933

Items of cost	Output per factory in thousands of pounds						All factories
	Under 100	100 to 199	200 to 299	300 to 399	400 to 499	500 and over	
Plant wages	cents 1.36	cents 1.32	cents 1.05	cents .90	cents .79	cents .76	cents .91
Materials and miscellaneous							
Boxes and liners	.49	.45	.40	.41	.45	.45	.43
Supplies	.32	.20	.22	.19	.27	.18	.20
Power, light and fuel	.37	.30	.32	.32	.30	.29	.31
Repairs	.15	.18	.14	.15	.10	.10	.13
Grading cream	.09	.11	.12	.16	.13	.11	.12
Sundry	.05	.04	.08	.08	.05	.05	.06
Total	1.47	1.28	1.28	1.31	1.30	1.18	1.25
Overhead							
Taxes	.12	.05	.07	.07	.06	.07	.06
Insurance	.13	.10	.08	.08	.06	.05	.07
Depreciation	.56	.32	.27	.29	.22	.19	.25
Interest	.45	.26	.24	.26	.18	.17	.22
Total	1.26	.73	.66	.70	.52	.48	.60
Administration							
Salaries	.40	.20	.23	.24	.22	.32	.27
Office supplies	.05	.06	.09	.06	.06	.04	.06
Postage and phone	.11	.10	.09	.14	.14	.16	.13
Travelling	.06	.04	.02	.03	.03	.03	.03
Head office	.08	.10	.05	.17	.28	.10	.12
Sundry	.03	.06	.05	.07	.03	.11	.08
Total	.73	.56	.53	.71	.76	.76	.69
TOTAL COST	4.82	3.89	3.52	3.62	3.37	3.18	3.45
Number of factories	4	14	22	19	5	14	78
Average pounds of butter	87,702	156,744	248,371	340,467	440,018	761,473	350,500

Overhead items, taxes, insurance, depreciation and interest also showed a marked decrease. The cost of materials and miscellaneous items remained fairly constant when expressed as a cost per pound butter. Cream grading charges vary because of the different systems of grading in vogue in the three provinces. In Manitoba, the charge includes the wages of a man who is stationed at the creamery and who aids in the plant as well as doing the grading. Alberta and Saskatchewan, on the other hand, employ graders who visit the creameries at intervals and who do not help in the creamery. Apart from the group containing the smallest factories, administration costs are higher in the larger plants. This is accounted for in part by the fact that there are more branch creameries under head office supervision in the larger production groups. More bookkeeping is required in larger plants, which requires the employment of more highly paid office staffs.

Large reductions in cost of manufacture occurred from the first to the third group of factories and then a rise from 3.52 to 3.62 cents occurred after which a decline to 3.37 and 3.18 took place. Apparently, after a 300,000 pound capacity was reached, more equipment and space were needed. This is indicated by the rise in overhead costs from .66 cents per pound in the 200–299 thousand pound group, to .70 cents in the 300-399 thousand pound group. Another reason for the higher cost in the fourth group was the increase in head office charges due to a greater number of branch factories in this group.

The cost of manufacturing in the 78 plants averaged 3.45 cents, the average production being 350,500 pounds. Thirty plants in Alberta with an average production of 316,303 pounds had a cost of 3.56 cents per pound butter. The average production in twenty-five Saskatchewan plants was 404,178 pounds and the cost 3.47 cents. The cost in Manitoba was 3.28 cents in 22 plants producing an average of 336,757 pounds of butter. Overhead and administrative costs were much lower in Manitoba than in the other two provinces. The greater volume of production in Saskatchewan brought costs per unit in this province lower than those in Alberta.

Transportation Costs.—Cream transportation costs for factories of various sizes are shown in Table 2. About one-third of the cream going to creameries was trucked, one-third expressed, and the remainder delivered by the producers. In very small factories producers delivered about 60% of the total cream received by the factories while in larger factories only 25% was delivered and 75% was either trucked or expressed to the creamery.

The cost of trucking in most cases was over 2 cents per pound butter fat and averaged 2.25 for all cream trucked. The cost of expressing cream averaged 1.74 cents per pound butterfat. Cartage charges on cream delivered by express averaged .05 cents per pound butterfat. The cost of trucking, railway express and

TABLE 2.—COST OF TRANSPORTING CREAM

Size of factory (1,000 lbs. butter)	Percentage of butterfat			Cost per lb. B.F.		Total transport (2) cost	
	(1) Trucked	Expressed	(1) Delivered	Trucking	Expressing	Butterfat transported	Butterfat used
						per lb.	per lb.
Under 100	16.6	22.6	60.8	2.66	1.66	2.14	0.84
100–199	18.4	23.9	57.7	1.86	1.66	1.81	0.76
200–299	32.1	24.2	43.7	2.32	1.45	2.00	1.11
300–399	33.3	33.5	33.2	2.22	1.61	1.98	1.37
400–499	28.1	45.4	26.5	2.25	1.46	1.84	1.29
500 and over	33.9	42.1	24.0	2.27	1.97	2.25	1.66
All factories	31.3	34.8	33.9	2.25	1.74	2.08	1.37

(1) "Delivered" means hauled to factory by the producer while "Trucked" means hauled by hire at the factory owners' or producers' expense.

(2) Total cost of transportation includes cost of trucking, express, cartage and bonuses paid on delivered cream.

cartage amounted to 2.08 cents per pound butterfat on all cream so handled. The total charge divided by all cream used in the manufacture of butter amounted to 1.37 cents per pound butterfat.

Return to Producer and Factory.—The producers of butterfat received about 70% of the factory value of the butter. The percentage return did not vary materially between factories of various sizes.

The return to producers in factories producing under 100,000 pounds of butter was only 14.40 cents per pound butterfat compared to 15.51 cents in factories producing 200–299 thousand pounds and 15.36 cents in plants with a production over one-half a million pounds. Cream gathering costs were much higher in the larger

TABLE 3.—RETURN TO PRODUCER AND TO FACTORY PER POUND OF BUTTERFAT

Return or cost per pound butterfat	Size of factory (1,000 pounds of butter)						
	Under 100	100–199	200–299	300–399	400–499	500 and over	All factories
	(Cents per pound)						
Net to producer	14.40	15.09	15.51	15.23	15.24	15.36	15.31
Hauling and express	.82	.74	1.09	1.33	1.24	1.59	1.32
Cartage	.02	.03	.02	.04	.05	.07	.05
Commission on cheques	.22	.21	.15	.16	.23	.21	.19
Total cost butterfat	15.46	16.07	16.77	16.76	16.76	17.23	16.87
Manufacturing cost	5.92	4.72	4.29	4.42	4.06	3.91	4.21
Total cost of butter	21.38	20.79	21.06	21.18	20.82	21.14	21.08
Selling price	20.66	22.15	22.24	21.98	21.54	23.20	22.46
Less selling cost	.37	.70	.76	.61	.47	1.10	.82
Selling price at factory	20.29	21.45	21.48	21.37	21.07	22.10	21.64
Profit or loss	−1.09	.66	.42	.19	.25	.96	.57
Percentage factory price returned to producer	71.0	70.4	72.2	71.3	72.3	69.5	70.8
Number of factories	4	14	22	19	5	14	78

plants causing the total cost of butterfat at the plant to be high. However, manufacturing costs were much higher in the smaller factories so that the total cost of producing butter did not vary greatly between plants of different sizes. When selling costs were deducted from selling prices, the price of butter at the factory was 22.10 cents in the largest creamery group and 20.29 in the smallest group. Selling costs include printing charges, freight on butter, storage, selling commissions, bad debts and advertising. The largest creameries made the most profit per pound butterfat, while those in the second and third groups made the next highest profits. The group under 100,000 pounds had a loss of 1.09 cents per pound butterfat.

Among the factories producing less than 100,000 pounds, producers received .91 cents per pound butterfat less than the average; the cost of manufacture was 1.71 cents higher than the average; returns were 1.35 cents less per pound butter on a butterfat basis and large deficits were shown. In the group manufacturing 100–199 thousand pounds of butter, producers received .22 cents less than the average for butterfat but factory returns were slightly above the average. Factories in the third group paid producers more than those in other groups but received less profit than the average. In the next three groups, higher costs of cream transportation offset to a large degree the lower costs of manufacture brought about by greater volume. The largest factories, however, paid more than the average for butterfat, had much higher cream transportation costs and received the highest profit. This was accomplished through lower manufacturing costs and higher returns for butter.

THE UNITED FRUIT COMPANIES OF NOVA SCOTIA, LIMITED, AND SUBSIDIARY COMPANIES

A. E. Richards[1]

The United Fruit Companies of Nova Scotia, Limited were formed in 1912 by special Act which provided for the federation of local co-operatives under a central selling agency. The original 22 locals increased to 50 and the company in its peak years handled about 42% of the commercial production of the Province. Of the 50 local warehouses, three are out of business today; the central company has taken over the business of two locals; and six locals, while still shareholders in the United, ship their fruit independently. Today it is estimated that the United handles about 25% of the exported fruit.

Affiliation between the central company and locals seems quite loose and patronage is maintained through service rendered. There is no contract binding the local to ship through the United Fruit Companies except in a few cases where the local is heavily in debt to the central. Some of the subsidiary companies use the facilities of the United Fruit Companies when it is to their advantage in buying supplies but enter into competition with the parent company in the marketing of fruit. According to the by-laws of the companies, they are supposed to be bound to ship through the central company but this clause has never been enforced. For the most part the subsidiary companies which are shipping independently have young and agressive types of managers and are financially independent of the United Fruit Companies.

There was a general pool of returns on fruit shipped through the United Fruit Companies up to the season 1923-24. Some locals claimed they were being handicapped by pooling returns with the inefficient packing house. The system was changed at that time to separate pools for each local.

The function of the central company is to sell the fruit packed by the local. It arranges for cars, space on the steamer, and looks after billing and insurance. It does the actual selling, receives account sales and works out returns on grades and varieties for each local warehouse. It looks after telegrams and cables, and maintains an overseas representative. A deduction of 5 to 7 cents per barrel of apples handled is made to cover this expense. For the season 1933-34 the deduction amounted to 6 cents, with a rebate of 1 cent.

Charges to grower per barrel of apples shipped from Port Williams, N.S., and consigned to a broker in London, Eng., Season 1933–34, Sterling rate at par

	$	$
Barrel, average cost to grower		.30
Local packing house charge		.22
Sales agency expenses:		
Rail Port Williams to Halifax	.155	
Insurance	.01	
Inspection	.015	
Head Office (United Fruit Co.)	.05	
Total		.230
Overseas expenses:		
Ocean freight	.5725	
Consolidated charges*	.426	
Broker's commission at 3% on gross sales value of $3.30	.099	
Advertising	.005	
Sampling	.008	
Total		1.110
Total Charges		1.860

*Consolidated charges include dock, wharf and port charges, warehousing, sorting, sale expenses, delivery, etc.

[1] Agricultural Economist, Economics Branch, Department of Agriculture, Ottawa.

Apples were consigned to about 35 brokerage firms in the United Kingdom in 1933-34. About 65% were sold by auction and the balance by private treaty. Sales to the Continent were direct on a F.O.B. Halifax basis. Below is an itemized list of charges to the grower on a barrel of apples shipped from the province of Nova Scotia to the overseas market.

All overseas charges are paid by the consignee and deducted from the sales price. An account sales, usually with cheque for net proceeds attached, is forwarded by consignee to the United Fruit Companies. Here the sales agency expenses are deducted and the statement forwarded to the packing house. The packing house takes off its charge for packing (which varied among packing houses from 15 cents to 25 cents in 1933-34) before return is made to the grower. The packing house does not supply the package. Out of his return from the packing house the grower must pay for the barrel which in 1933 cost him 30 cents on the average.

The United Fruit Companies acts as a wholesale supply house for its member locals and carries on a considerable trade outside its own companies. The general practice seems to be to advance supplies to member locals in the spring of the year, consisting mainly of fertilizer and spray material. This is carried as a book account without interest and deducted from the apple account of the local in the fall when proceeds from sale of fruit come in. These proceeds in turn are used to reduce accounts payable by central.

Sales and Distribution.—Sale of fruit and factory products by the United Fruit Companies in 1933-34 amounted to over $1,300,000 and sales of supplies to slightly over $320,000. The total number of barrels of apples handled amounted to 696,504 of which 638,447 or 91·7% were shipped to markets and 58,057 or 8.3% were turned into by-products. Of the total shipped to market, 36,799 barrels or only 5.8% were sold in Canada. Of the total export shipments, 496,567 or 82.5% went to the United Kingdom. During the past few years the United Fruit Companies has handled approximately 25% of the apples exported from the province. Below is a summary of shipments as appearing in the report of the twenty-second annual meeting of the Company.

DISTRIBUTION OF APPLE SHIPMENTS MARKETED BY UNITED FRUIT COMPANIES OF NOVA SCOTIA, LIMITED, SEASON 1933–34

	Barrels	Half barrels	Boxes and hampers	Equal in barrels
United Kingdom	165,536	10,236	554	170,839
London				
Liverpool	119,279	605	62	119,602
Manchester	93,091	365	1	93,274
Glasgow	30,098	49	1	30,122
Cardiff	35,830	252	291	36,053
Bristol	13,442			13,442
Newcastle	22,787	36	2	22,806
Hull	6,220			6,220
Southampton	4,011			4,011
Belfast	200			200
Total to United Kingdom	490,494	11,543	911	496,569
Outside United Kingdom				
Continental Europe	100,820			100,820
Palestine	110		10	113
Alexandria		12		6
Newfoundland	3,293	30		3,308
Bermuda	841			841
Local Sales	36,290	749	375	36,790
Total to all markets	631,848	12,334	1,296	638,447

Manufacture of Fruit Products.—The United Fruit Companies of Nova Scotia Limited are engaged extensively in the manufacture of fruit products. Of the total volume of the 1933 crop handled, 8.3% was turned into fruit products in the form of canned and dehydrated apples, vinegar and cider. In the Union Dehydration plant at Port Williams, 457,770 pounds of evaporated apples were manufactured using in the operation a total of 37,100 barrels. The greater portion of the manufactured product was sold in Germany. A number of car loads were also shipped to England and the balance of the stock was sold on the local markets. All of this product was sold before June at a profitable price and additional orders could not be filled. The factory at Aylesford used the following quantities of raw products in the different manufactured lines: apples 20,597 barrels, pears 948 barrels, plums 342 bushels and string beans 18,626 pounds.

Supplies.—In its endeavour to supply materials at a lower cost to its members and as a check on private trading, the Co-operative has shown initiative and enterprise. It constructed a plant for the manufacture of lime sulphur in which 102,920 gallons of this product were made in 1933. In another plant dust insecticides are being manufactured and large quantities of spray materials are purchased in wholesale quantities which are supplied to locals at cost. Twenty-three different spray material items were handled which in total quantity amounted to 358 gallons, 2,573 barrels and 1,630 tons. Other supplies handled included 3,448 barrels of flour, 23,253 bags of feed, 3,000 bags of seed oats and a considerable quantity of coarse grains and small seeds. Sundry merchandise included apple graders, shingles, roofing, fruit wraps, spray hose, fibre board, nails and two million pulpheads.

The Financial Statement.—The financial statement of the United Fruit Companies of Nova Scotia Limited for the year ending May 31, 1934, shows total assets amounting to $270,163 of which $81,218 are invested in plant and equipment and $177,316 are included under the item of current assets. Liabilities to the public amounts to $217,308 which contains the large item of $104,711 in accounts payable. At the end of May when the financial statement is prepared relatively heavy commitments for fertilizer, spray material and other orchard supplies have been made and bank loans have been incurred for financing. At another season of the year accounts receivable, bank loans and accounts payable would probably be considerably reduced and would not appear so ominous. The gross operating margin for the year amounted to $41,559 out of which expenses of $40,506 were paid leaving a net operating income for the year of $1,053 which was transferred to surplus account. Notes of subsidiary companies on May 31, 1934, shown as indirect liability in the Balance Sheet of the United Fruit Companies amounted to $149,198.00. In general these notes are for 3 months. The local pays the interest and looks after renewal.

Central Company and Local Relationship.—Poor management was responsible for bad financial conditions of a number of locals. Managers in past advanced supplies and cash to members on too liberal a scale. Some of this was used for other purposes than financing the crop. The grower was unable to settle his account and there was a gradual accumulation of such accounts on the books of companies. The banks shut down on further credit direct to growers or to companies. For the carry-over of debts and for fresh advances of supplies, banks demanded the personal guarantee of Directors of locals and endorsation of the Central Company. Out of the situation grew the present practice of giving a promissory note signed by the Directors to the Central company for supplies advanced. The note is in turn endorsed by the United Fruit Companies and discounted at the bank.

The United Fruit Companies does more than sell apples for its subsidiaries, it is a banking institution. It is probably too kind to its locals, but has under present management been supporting the weaker companies, holding locals in check and gradually improving their position. Subsidiary companies' directors paper under discount has been reduced from over $230,000 in 1928 to $149,198. The parent company absorbs many charges for the locals. In order to get apples properly grown and

of the right grade it has to furnish fertilizer, spray material and other supplies. These advances are carried as current book accounts in many cases for five or six months for the locals without interest. The central company gets advances on apples from overseas brokers which in turn are advanced to locals. The United Fruit Companies absorbs all interest charges which have become an extremely heavy item of expense.

Many of the companies which drifted into heavy indebtedness are under new management since 1928 or 1930 and are showing gradual improvement, but there is still a need for more definite and systematic debt reduction.

FINANCIAL STATEMENTS

W. F. Chown[1]

An adequate record of cash transactions is a necessity in the preparation of the Income and Expenditure Statement. For this purpose, it is highly desirable to cultivate the habit of securing a voucher for each transaction at the time it takes place. These should be fyled in some orderly fashion. Statements and account sales rendered by companies to whom products are sold or shipped, and invoices for purchases are good vouchers. A receipt should be given when money is received and the particulars entered on the stub. When payments are made by cheque, the stub should be completed. Failing the foregoing, pencilled memoranda are useful and a pad and pencil in the barn or the time-honored kitchen calendar have their place in building up an adequate record but do not in themselves make up that record. From these original records, the cash book should be written up as frequently and regularly as possible by the farmer, his wife, son or daughter.

Personal expenses have no part in the farm accounts. Because it is seldom possible for the farmer to keep personal and farm money separate, a system of family budgeting, where a definite amount each week, or the proceeds of the cream cheque, or egg and poultry receipts or both are handed over to the wife, simplifies this difficulty.

For the individual having a bank account, it will probably be satisfactory to consider this and cash together. For the business being operated for others by a manager, all receipts should be deposited in the bank intact and all payments made by cheque.

A Farmer's Account Book may be obtained from the Publicity and Extension Branch, Department of Agriculture, Ottawa, at the nominal charge of ten cents. It contains detailed instructions for account keeping during the year and for closing the accounts at the end of the year. It is quite simple and wholly adequate for the average farmer.

The Columnar Cash Book.—For farms operated by managers, farmer's clubs, co-operatives and those individual farmers, who are anxious to keep exact records, a columnar cash book is recommended. A columnar book may be purchased with the desired number of columns, or an ordinary note book may be ruled as required. The purpose of such a book is to classify receipts and payments into whatever groupings are desired. This is achieved by having a separate column for each class of transaction that occurs with any frequency and a sundry column for such transactions as do not recur. Receipts should be recorded on the left hand page and payments on the right. If it is desired to subdivide payments to an extent greater than can be accommodated on one page, receipts can be recorded in one part of the book and payments in another, spreading the latter over two pages. The columns may be totalled at any time showing the receipts and payments to date.

---

[1] Accountant Examiner, Economics Branch, Department of Agriculture, Ottawa.

The first entry on the receipts page will be the balance brought forward and so the difference between receipts and payments at any time should equal the cash on hand. The book and cash should be balanced as regularly as possible. Where it is not in balance, the amount of the difference will usually suggest some transaction that has been omitted. Further arithmetical proof of accuracy can be obtained by cross-adding the totals of each page. The totals of the distribution columns should equal the total of the cash column.

Columnar Cash Book Illustrated.—The following examples could be varied to meet most any requirement, and in particular might be arranged by departments as Cattle, Hogs, Poultry, Crops. For the individual, a column for personal payments would be added.

CASH RECEIPTS

Date	Particulars	Sundry Cr.	Milk Cr.	Cream Cr.	Eggs Cr.	Live Stock Cr.	Crops Cr.	Cash Dr.
1934								
April 1	Balance brought forward	625.00						625.00
3	Creamery March 15–31			3.00				3.00
10	Dairy March milk		80.00					80.00
15	Store 20 doz. @ 20c.				4.00			4.00
16	Drover 1 veal calf					8.00		8.00
17	Neighbor 30 bus. barley						24.00	24.00
20	Township 3 days roadwork	15.00						15.00
1935								
March 31	Store 10 doz. @ 21c.				2.10			2.10
	TOTAL	700.00	1,100.00	55.00	65.00	250.00	180.00	2,350.00

CASH PAYMENTS

Date	Particulars	Sundry Dr.	Wages Dr.	Repairs Dr.	Milk cartage Dr.	Feed and seed Dr.	Harvest expense Dr.	Cash Cr.
1934								
April 2	Blacksmith			3.00				3.00
6	Seed merchant, 2 bus. clover					30.00		30.00
11	Trucker 4700 lb. @ 30c.				14.10			14.10
	Implement dealer—seed drill	170.00						170.00
30	Manager		40.00					40.00
	Hired man		20.00					20.00
1935								
March 31	Balance on hand	114.50						114.50
	TOTAL	1,021.90	806.00	43.00	194.10	220.00	65.00	2,350.50

The Cash Account.—The analysis of the Sundry Payments column is as follows:— Fertilizer $40.00, Phone $20.00, Insurance $30.00, Taxes $150.00, Seed Drill $150.00, Horse $150.00, Mortgage Interest $240.00, and Miscellaneous $107.40. The following statement can be prepared to summarize the year's cash transactions.

THOMAS BROWN

STATEMENT OF RECEIPTS AND PAYMENTS
for the year ending March 31, 1935

Balance on hand, April 1st, 1934,	$ 625.00	Wages,	$ 806.00
Milk	1,100.00	Repairs,	43.00
Cream,	55.00	Milk cartage,	194.10
Eggs,	65.00	Feed and seed,	220.00
Live stock,	250.00	Harvest expense,	65.00
Crops,	180.00	Fertilizer,	40.00
Miscellaneous,	75.00	Phone,	20.00
		Insurance,	30.00
		Taxes,	150.00
		Mortgage Interest,	240.00
		Purchase of seed drill,	170.00
		Purchase of horse,	150.00
		Miscellaneous,	107.40
		Balance on hand, March 31, 1935,	114.50
	$2,350.00		$2,350.00

Limitations of Cash Statement.—The cash statement, while required by statute for insurance companies and usually for municipalities, is of very little accounting value. It fails to show the income earned during the period or the expense incurred earning that income and the resulting profit or loss. Its usefulness is limited to non-profit organizations, which own no property and do not use or extend credit such as the smaller farmer's clubs. Complete cash records are very essential, however, in the preparation of the Income and Expense statement.

ECONOMIC RESEARCH IN PROGRESS

The Economics Branch of the Dominion Department of Agriculture has six major research projects under way at the present time. The majority of these studies are carried on co-operatively with other Branches of the Dominion Department or in co-operation with Provincial Departments and Universities.

An example of research in marketing is found in the analysis of operating costs of creameries in the Prairie Provinces which is discussed in more detail elsewhere in this issue of the Annalist and which need not be discussed further in this article.

Another type of marketing research is that of the analysis of consumer demand for cheese and milk. This work is now being carried on in Quebec City, Oshawa, Ontario, and Calgary, Alberta. In these cities, representatives of the Branch are calling on substantial numbers of housewives, proprietors of hotels and restaurants for the purpose of securing data regarding kinds of cheese consumers prefer, what packages are preferred, what factors tend to decrease or increase consumption, how cheese is served in homes, and other factors which influence the demand for cheese. Similar data are being obtained in regard to milk. When analysed, these data will provide valuable information for housewifes, retail stores, restaurants and hotels as well as producers and distributors of these products. A knowledge of consumer preferences is essential in any marketing program and these studies provide suca basis.

This project is being carried on in co-operation with the Dairy Branch at Ottawa. In Quebec, the Rural Economics Service is assisting in obtaining the data. In the other provinces, provincial officers are aiding the project through their personal knowledge of local conditions and in facilitating the collection of the records.

For several years past, this Branch has been collecting data regarding Farmers' Business Organizations. Such data include the nature of the business, volume of

sales, operating expenses, form of organization, number of members, capital structure and other pertinent facts. Comparative efficiency of operation has been analyzed in dairy marketing concerns and in fruit companies. Much factual data has been compiled which is constantly in demand by those interested in the program of such organization as well as others. In the Provinces of Quebec, Ontario and Saskatchewan, this work is conducted in co-operation with Provincial Departments but in all the other Provinces, the Economics Branch makes direct contact with the organizations.

Another type of study is under way in the St. John Valley of New Brunswick where 200 potato growers have co-operated with the New Brunswick Department and the Branch in securing data which will provide information on expenses of production, farm receipts, utilization of land, cropping practices and organization of the farms. Thus, much helpful information is anticipated which should be of assistance in making any necessary adjustments in production in this area.

In Western Canada, two land utilization projects are under way. Both of these studies bear a direct relationship to the drought areas and an effort is being made to relate farm practices and income to soil type. With this in mind, the economic survey and soil surveys are being linked up. This work is part of the whole program of rehabilitation in the Prairie Provinces and part of the funds for these studies is provided for under the Prairie Farm Rehabilitation vote.

In Alberta, data have been secured from 500 farms situated between Vulcan, Lomond, Wheat Centre, Vauxhall and Barrons. These records include crop history, yields, prices, farm receipts, expenses, indebtedness, carrying capacity of grazing land, size of holdings, abandonment and its causes. Besides these, municipal receipts and expenditures, assessments, tax arrears and relief expenditures are being analysed. Thus, the economic possibilities of an area may be appraised for agriculturel purposes and a policy of land utilization evolved.

In this project, the University of Alberta is a co-operating agency. The general direction of the study is effected through a committee of Dominion Department of Agriculture and Alberta Government officers.

In Saskatchewan, a somewhat similar study was initiated by the Department of Farm Management at the University. The Economics Branch joined forces with the University and as a result, 800 farmers have contributed information on an area surrounding Chaplin, Coderre, Gravelbourg, Shamrock, Lafleche, Wood Mountain and Glentworth. These two studies in the Western Provinces are sectional but provide a very complete cross section of larger areas.

One of the older sections of the country is Antigonish County, Nova Scotia. At the request of the College of Agriculture at Truro, the Economics Branch has assisted in planning and carrying into effect a project which includes both economic and social problems. In many respects, it represents an effort of a community to help itself for various agencies are co-operating in carrying the project into effect. Besides the two research bodies already mentioned, St. Francis Xavier University has been active in its support. Municipal officers have assisted in deciding upon what problems should be studied and in providing data for analysis for research agencies. Already 150 records have been obtained from farmers in the Heatherton, St. Andrews and Pomquet areas which will enable analysis of farm business enterprises including part-time farming. Information is being secured not only regarding agriculture but also with respect to local industries which are dependent upon or related to the agriculture of the area.

G. H. Craig, C. C. Spence, I. S. MacArthur and G. Boucher have been appointed Field Assistants, Economics Branch, Department of Agriculture, Ottawa. Messrs. Craig and Spence are engaged in land utilization work in Alberta and Saskatchewan respectively, Mr. MacArthurer in a study of potato production in New Brunswick, and Mr. Boucher in an analysis of consumer demand for cheese and milk in Quebec City.

Erratum.—In the June issue of the Economic Annalist, an error occurred which should be corrected. On page 29, reading from the bottom of the page, line 12 reads "by more than 10% per annum," this should read "by more than 1% per annum."

SUBSIDIARY CREDIT CORPORATION OPERATED BY CO-OPERATIVE

The Co-operative Grange League Federation, commonly called the G. L. F., is a successfully operated farmers' co-operative functioning throughout the area covered by the New York City milk shed. It was created in 1919 by the amalgamation of farmers' forces as expressed in The Grange, the New York Dairymen's League and the Federal Farm Bureau Federation, It functions primarily as a consumers' co-operative handling feed, seed, fertilizer, binder-twine, paint and spray materials; it is also a producers' marketing co-operative merchandising locally-produced farm products such as beans, eggs, grain and hay. It serves 110,000 patrons and in 1934 conducted a business turnover of above 20 millions of dollars. It reaches its patrons by means of 132 G. L. F. service stores and 570 G. L. F. agencies. The business is conducted through the co-operative G. L F. Holding Corporation and four subsidiaries, the G. L. F. Mills, the G. L. F. Marketing Corporation, the G. L. F. Credit Corporation and the G. L. F. Products Corporation.

Operate on Cash Basis.—The work of the Co-operative G. L. F. Credit Corporation has made it possible during the depression years to change from a policy wherein much business was done on a credit basis to one wherein all business is conducted on a cash basis.

Statements of the organization show that in 1930–1931 prior to the adoption of the cash policy, it cost 73 service stores as much money to handle their credit as it did the G. L. F. to pay a 6% dividend on its total capital stock. Their executives state that no business giving credit can avoid these costs which, if the business is to remain solvent, must be borne unjustly by those who pay their bills. This corporation deals with a form of credit which is not associated with buying or selling but which is a transaction in itself. Money is loaned to individual farmers on the basis of financial statements which set forth the personal assets and liabilities of the prospective borrower. An application with the statement attached is sent to the office of the Credit Corporation. A check-up of the character and ability of each applicant is made through key men in each community. If the reports concerning the applicant are satisfactory and the officers of the credit corporation approve, the application is endorsed by the corporation and forwarded to the Federal Intermediate Credit Bank at Springfield. The application is again considered at this point and, if approved, the amount of money less interest in advance is forwarded to the credit corporation and then passed on to the borrower.

These credit corporations are merely companies incorporated under the laws of the state with power to make loans to farmers and to rediscount these loans with the federal intermediate credit banks. The intermediate credit banks get their funds by selling their debenture or notes on the money market.

This method of securing credit has been used by thousands of G. L. F. patrons. Loans will only be made for wise productive expenditure. It puts the borrower in a position to pay cash. He secures the advantage of volume buying, is not forced to sell products in distressed markets and he can finance larger operations.

THE ELEVENTH AMERICAN INSTITUTE OF CO-OPERATION

The American Institute of Co-operation held its eleventh annual session at Cornell University, Ithaca, N.Y. July 15th to 20th. Over one thousand persons registered at the Conference which was declared one of the most successful in the history of the Institute. At this important educational gathering, co-operative leaders from many parts of the world were represented.

The dominant note of the Institute this year was how to improve the business practices of co-operatives. Eleven comprehensive topics embracing subjects of vital importance to co-operative leaders and workers were chosen for discussion. Group meetings were held concurrently under a chairman and discussion leader. The instructional method was followed. Lectures were the feature of the morning sessions which were co-ordinated under a leader with general discussion in the afternoon.

Among the topics under discussion were: *Co-operative publications, egg marketing, membership relations and field service, problems of dairy marketing, efficient management*

of retail service for farmers, the practical application of the philosophy of co-operation, business management for co-operative associations, co-operative credit for farmers and co-operatives, and *marketing fruits and vegetables.*

The afternoon and evening sessions of the last two days were devoted largely to a conference of monetary policies. Dr. G. F. Warren of Cornell University opened the program with a lecture on "The Relation of Supply of and Demand for Gold to Commodity Prices." This was followed by two papers on "Monetary Policies and their Effects upon Prosperity in Various Countries" by Professor O. M. W. Sprague, Harvard University and Professor J. H. Rogers, Yale University. The international monetary situation was discussed by James David Mooney, President of the General Motors Export Company. Mr. J. D. Barnum, President of the American Newspaper Publishers Association, presented "How a Publisher Looks at the Agricultural Co-operative Movement." Judge J. D. Miller, President of the National Co-operative Council, spoke on "The Philosophical and Legal Background of the Co-operative Movement in the U.S.A." Mr. H. E. Babcock, Manager of the Co-operative Grange League Federation Exchange discussed the scope of the co-operative movement in the U.S.A. At the final conference under the chairmanship of Mr. Harper Sibley, President of the United States Chamber of Commerce, Dr. Lionel D. Edie presented a paper on "International Stabilization."

Space will not permit a discussion of the papers which are printed in full in the Institute Proceedings.

Recent statistics show 10,900 farmers' co-operatives in the United States which in 1934 had 3,156,000 members and handled approximately $1,365,000,000 worth of business. The Institute may be regarded as a college for the exchange of experiences by trained leaders and students who are working and interested in the school of co-operative thought and endeavour. This school may be divided into two groups, the operating group and the philosophic group. The recent conference was largely an operating group program. Practical questions of business management, operating costs and net savings were discussed.

ECONOMIC LITERATURE

CORBETT, R. B. A study of the Costs and Returns from Grading Vegetables. Bulletin 249, Agricultural Experiment Station, Rhode Island State College, Kingston, Rhode Island.

The New England States were fearful for their vegetable market because of out-of-area competition. To meet the situation, it was decided to grade the local products to a standard above normal farm grades and thus save their markets for themselves. Standards were fixed and some growers became skeptical of their utility. This led to a study of the situation during the crop years of 1930 and 1931 with the result as published in this interesting 48-page bulletin. The general conclusions of the study would indicate that the law of diminishing returns appears to apply in connection with the grading of certain vegetables. The products selected for study were hothouse tomatoes, field tomatoes, bunched beets, bunched carrots, cucumbers and peppers. The grading and packing of all of these products were done under the usual practical and competitive conditions on the farm. Costs were made up almost entirely of labour and packages, since no special buildings or equipment were used.

The products which had been rigidly graded usually commanded a higher price than the normal farm graded produce but in most cases, the cost of packaging was greater than the additional return secured.

Crops which had been excellently grown gave some encouragement to the rigid grading as there were few culls, requiring a small amount of extra labour to grade to a high standard. More important still was the small percentage of the product which had to be sold at low prices as seconds or culls. With the crops studied, several pickings, pullings or cuttings were necessary before the entire crop was harvested. As the season advanced, there was a great reduction in the percentage of the crops harvested which met the rigid grade requirements. Only a few buyers were interested in highly graded and carefully sized bunched beets and carrots to the extent of paying

premium prices. In some cases, these products fetched lesser prices than the farm graded products. Rigid grading apparently yielded its best results on a relatively over-supplied market and with the higher priced commodities, such as tomatoes and peppers.

The author states that the study has been criticized because only one set of standards was used and states that a single set of standards applied to different crops gives as many situations as there are crops.

In both years, the receipts of shipped in tomatoes ceased entirely during much of the local season. The price also fell rapidly as the local supply increased rising again as the local supply disappeared. The price appears to have been so low during the local season that the out-of-area shipper was eliminated.

NOTES

A. W. Street, Ministry of Agriculture and Fisheries, speaking at a Conference of Agricultural Organizers held at Cambridge, June 26th, 1935, said in part "Even if, faced as we are with so many practical difficulties, we were tempted to feel despondent of the future, we should find good cause for encouragement by noticing the extent to which the principles underlying our program of marketing reorganization are being applied elsewhere. New South Wales and Queensland have for some years had a system of State marketing boards for primary commodities in many ways analogous to our own. New Zealand has successfully regulated the export of a large number of primary commodities through Dominion Produce Boards, and, in consequence of the report of the recent Dairy Produce Commission, appears to be moving towards a much more direct regulation of production, processing and marketing both locally and for export. But perhaps the most interesting recent development in the Dominions has been the formation in Canada of a Dominion Marketing Board under the terms of the Natural Products Marketing Act, 1934. The Dominion Board is the co-ordinating and controlling authority for provincial and federal marketing organization with powers either to accept schemes put forward by producers or itself to initiate schemes. Already, parallel Provincial Marketing Acts have been passed in most of the Canadian Provinces, and a number of important schemes have been brought into operation. But the powers of the Dominion Marketing Board go beyond the organization of primary marketing, for it may investigate costs of production, wages, and wholesale and retail margins, while the control of import, export and interprovincial trade is also envisaged. It is evident that Canada intends to move far and fast in the direction of organizing agriculture and the distribution of foodstuffs."

Officers of the Canadian Society of Agricultural Economics elected at the annual meeting held at the University of Edmonton, June 24–27, were as follows:— President, H. C. Bois, Rural Economics Service, Department of Agriculture, Quebec City; Vice-President, T. W. Grindley, Agricultural Branch, Dominion Bureau of Statistics; Secretary-Treasurer, J. Coke, Economics Branch, Department of Agriculture, Ottawa; Committee, W. M. Drummond, Department of Economics, University of Toronto, Toronto, Ontario; F. W. Reinoehl, Canada Colonization Finance Corporation, Winnipeg, Manitoba; C. M. Collins, Agricultural Representative, Lawrencetown, Nova Scotia; and E. C. Hope, Department of Farm Management, University of Saskatchewan, Saskatoon, Saskatchewan.

The Canadian Wheat Board is composed of the following members: John I. MacFarland, Winnipeg, Chairman; D. L. Smith, Winnipeg and Dr. H. C. Grant, University of Manitoba. An advisory Committee representing farmers, the grain trade, and milling interests has also been appointed. C. B. Davidson, formerly of the Agricultural Branch, Dominion Bureau of Statistics, Ottawa and a member of the Dominion Marketing Board has been appointed Secretary.